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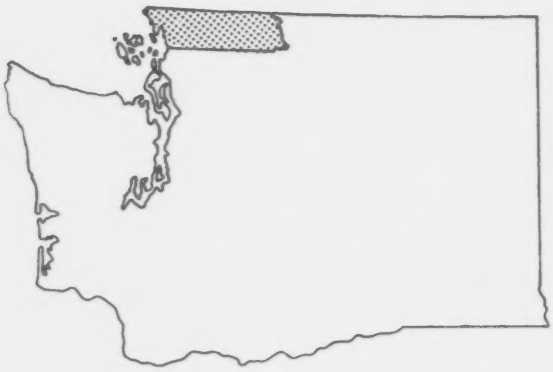
FLOOD INSURANCE STUDY

WHATCOM COUNTY, WASHINGTON
UNINCORPORATED AREAS



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Federal Emergency Management Agency

COMMUNITY NUMBER - 530198

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. The Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the unincorporated areas of Whatcom County, Washington. This information will be used by Whatcom County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic content of the original Flood Insurance Study was prepared by the U.S. Army Corps of Engineers (COE), Seattle District, at the request of the Federal Insurance Administration, U.S. Department of Housing and Urban Development. Authority and financing are contained in Inter-Agency Agreement No. 1AA-H-2-73, Project Order No. 4. The report format and maps for the original Flood Insurance Study were updated and certain supplementary data developed by Dewberry, Nealon and Davis, Consulting Engineers, in 1976 under Department of Housing and Urban Development Contract No. H-3675.

The hydrologic and hydraulic analyses for coastal areas adjacent to Birch Bay and Point Roberts for this study were performed by CH2M HILL Northwest, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-86-C-2229. This study was completed in July 1988.

1.3 Coordination

In order to secure a source of community input for the original study, the selection of the floodways presented in this report was coordinated with officials of the Whatcom County Planning Commission (WCPC). At the request of the WCPC, the original floodway design was modified to better meet the needs of the county. Background and historical flooding information was

supplied by the WCPC and by the Puget Sound Task Force, Pacific Northwest River Basins Commission.

The initial community coordination meeting for the Birch Bay and Point Roberts areas was held on January 16, 1986, and attended by representatives of FEMA, the study contractor, and representatives of Whatcom County. The meeting was held to explain the nature and purpose of the study, to outline the scope and limits of the work, as well as to obtain flood information currently available concerning the community.

The National Oceanic and Atmospheric Administration (NOAA) was contacted and provided annual and monthly maximum tide gage records for long-term stations at Friday Harbor and Cherry Point, Washington.

The COE's Seattle office provided aerial photographs for the study sites and tide and wind data for areas near the study sites.

The Whatcom County Public Works Department was contacted and provided information on past flood occurrences and maintenance concerns in the study areas.

Residents at the study sites and the manager of the Birch Bay Village Community Club were interviewed and provided information on past flood problems.

The Waterways Experiment Station Coastal Engineering Research Center (CERC), COE, Vicksburg, Mississippi, was contacted and supplied computer software and documentation for the analysis of wave generation and wave runup.

The Canadian Climatic Data Services organization provided long-term wind data from their station at Tsawwassen, British Columbia, just north of Point Roberts, Washington.

Several meetings between the study contractor and regional FEMA representatives were held to review study progress and clarify specific objectives.

The results of the study were reviewed at the final Consultation Coordination Officer's meeting held on November 7, 1989, and attended by representatives of Whatcom County, the study contractor, and FEMA. All problems raised at that meeting have been addressed in this study.

1.4 Acknowledgments

The assistance and cooperation of the WCPC and the U.S. Geological Survey (USGS) in supplying data and maps for the original report are gratefully acknowledged.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Whatcom County, Washington. Not included in the study are the incorporated Towns of Nooksack and Ferndale, and the Cities of Blaine, Bellingham, Everson, Lynden, and Sumas. Also excluded from the study are the Mount Baker and Okanogan National Forests, North Cascade National Park, Ross Lake National Recreational Area, Birch Bay State Park, Blaine Air Force Station, Larrabee State Park, Lake Terrell State Game Range, and the Lummi Indian Reservation. The area of study is shown on the Vicinity Map (Figure 1).

Portions of two major river basins are located within the area included in this study, the Nooksack and the Sumas. The Nooksack River is the main stream of the Nooksack Basin and generally flows in a westerly direction from its origin as the "North Fork" on the slopes of Mount Shuksan. Detailed studies were made to determine the flood hazard of the Nooksack River from Bellingham Bay to its confluence with the "South Fork," and the South Fork Nooksack River from its mouth upstream to Skookum Creek.

Approximate study methods were used to study the Samish River, the North and Middle Forks of the Nooksack River, and the following other streams and tributaries: Dakota, Bertrand, California, Swift, Breckenridge, Terrell, Dale, Ten Mile, Deer, Anderson, Silver, Squalicum, Carpenter, Olsen, Hutchison, Austin, Maple, Fishtrap, Chuckanut, Beaver, Fingalson Creeks, and Unnamed Stream A. These methods are applied to delineation of the boundaries of floods with a recurrence interval greater than 1 percent. (A flood for which there is a 1 percent chance of occurrence in any year is commonly called a 100-year flood.) These streams studied by approximate methods are in areas of limited economic or residential development.

The Sumas Basin is located in the north-central portion of the area included in this study. Detailed studies were made on the area between the Cities of Sumas, near the U.S.-Canadian border, and Everson, on the Nooksack River. This area is susceptible to overflow from the Nooksack River. Due to limited residential and economic development, approximate methods were used to determine the 100-year flood boundary for the other flooding sources within this basin -- Sumas River, Saar Creek, and their unnamed tributaries. Approximate methods were also used to determine the 100-year flood boundary for most coastal areas subject to tidal flooding.

All riverine studies were based on existing conditions and no consideration was given to future development and construction. Several streams in the county were not studied at all because development in these areas is not anticipated for at least 5 to 10 years.

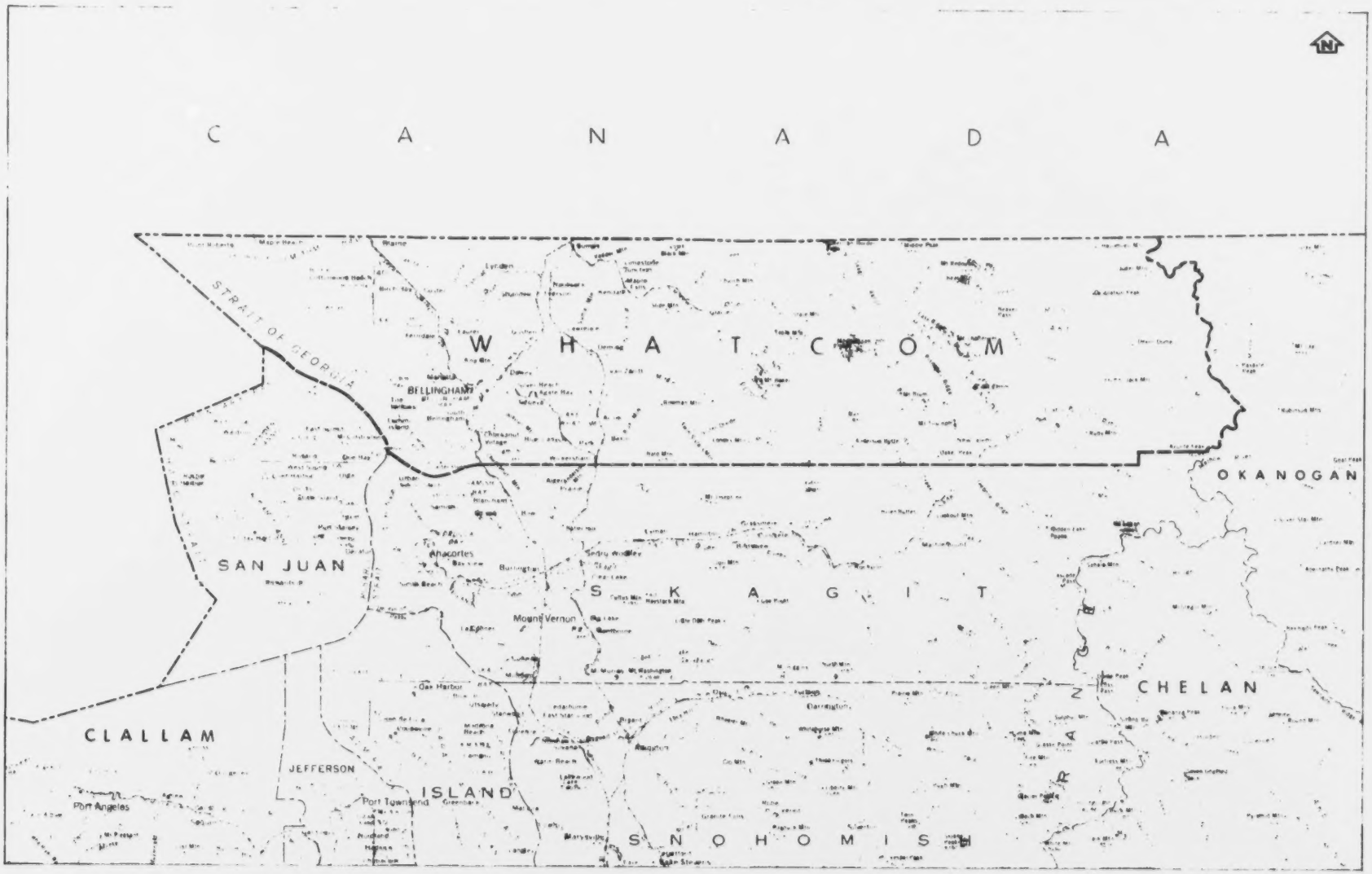


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINCORPORATED AREAS)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

Detailed methods for the study of coastal areas were used in the vicinity of Point Roberts and Birch Bay. The total reach involved approximately 11,000 feet of shoreline in the unincorporated areas of Whatcom County. The study areas include 7,000 feet of shoreline along Birch Bay and 4,000 feet along the south shore of Point Roberts. This study was restricted to developed coastal areas or areas of projected development. All results were based on existing conditions, and no consideration was given to future development or changes in the flood boundary, which may occur because of beach erosion and accretion.

2.2 Community Description

Whatcom County is located in the northwestern corner of Washington adjacent to the U.S.-Canadian border. The county has a land area of approximately 2,100 square miles of which approximately 1,350 square miles are under Federal control. Approximately 2 percent of the land is within incorporated urban areas, which are excluded from this study.

The population of Whatcom County increased from 60,355 in 1940 and 70,317 in 1960 to 88,100 in 1973. The latest (1980) estimate of the U.S. Census Bureau is 106,700 for the county. This indicates an annual growth rate of approximately 21.1 percent between 1973 and 1980 (Reference 1).

The topography of Whatcom County results largely from continental glaciation. Geologists estimate that 20,000 years ago the last continental ice sheet advanced into this area from what is now British Columbia. The ice flow, as much as 8,000 feet thick, sculptured the valleys and hills over which it passed and produced quantities of gravel from the exposed rock. As the ice melted, vast overflows washed these gravels downstream and out onto the lowland plains. At the time the land west of the Cascades was approximately 100 feet lower than it is today, and an arm of the sea extended eastward over the present locations of Lynden, Everson, Nooksack, and Sumas. Relieved of its glacial burden, the land rose, and the sea retreated, leaving remnants of prehistoric sandy beaches still clearly recognizable today.

The Nooksack-Sumas Basins comprise approximately 1,256 square miles of land and inland water in northwestern Washington. Of these 807,990 acres, 760,000 are in Whatcom County. The basins are bounded on the north by the Fraser River Basin in British Columbia, on the east by the Skagit River Basin in British Columbia, on the south by the Skagit and Samish Basins, and on the west by the Strait of Georgia. Elevations vary from 10,750 feet at the summit of Mount Baker and 9,040 feet at the summit of Mount Shuksan to sea level. The eastern parts of the basins are heavily timbered, mountainous terrain. West of the unincorporated area of Deming, the mountains drop sharply to the floor of a broad valley whose rolling surface varies from 400 feet to sea level.

The Nooksack River system rises in the vicinity of Mount Baker and Mount Shuksan, about halfway between the coast and the crest of the Cascade Range. The three major tributaries of the Nooksack are North, Middle, and South Forks, which flow through mountain valleys, joining near the unincorporated area of Deming to form the main stem.

The North Fork originates at a glacier on the east side of Mount Shuksan and flows 34 miles, west and south, to its meeting with Middle Fork. Middle Fork originates at a glacier on the southwest slope of Mount Baker and flows 17 miles northwesterly, joining with North Fork to form the Nooksack River. The South Fork enters 4 miles downstream. This tributary, which, although originating close to the source of Middle Fork, is not fed by glaciers, flows 38 miles in a wide arc south, west, and northwest before meeting the main river. From here the Nooksack River continues for 37 miles, following a semi-circular course curving north and then south before reaching its outlet in Bellingham Bay. Prior to 1860, the main stream flowed into Lummi Bay along what is now the Lummi River. A large log jam 4 miles upstream from the mouth of the Lummi caused an overflow into what had previously been a creek flowing into Bellingham Bay. This creek offered an easier route to the sea and the main channel has continued on this alignment ever since. Major tributaries to the Nooksack are Anderson Creek, entering near Lawrence; Bertrand and Fishtrap Creeks, entering near Lynden; Ten Mile Creek, entering near Ferndale; and Silver Creek, entering near Marietta.

The Sumas River Basin is approximately 20 miles long, has a maximum width of approximately 10 miles, and covers a total area of 143 square miles. Seventy-three square miles of the basin are in Whatcom County in the United States and the remainder in British Columbia, Canada. Within Whatcom County the Sumas River-Johnson Creek Valley is approximately 11 miles long and a maximum of 3.5 miles wide.

The Sumas River rises in the southern part of the basin and winds northward 19 miles to the international boundary, 18 river miles south of its junction with the Fraser River. The principal tributaries within Whatcom County are Johnson and Saar Creeks. Johnson Creek drains approximately 15,000 acres in the western part of the basin and flows northeasterly to the City of Sumas, then easterly 0.5 mile to its junction with the Sumas River. Saar Creek drains 11,000 acres in the northeastern part of the basin, and joins the Sumas in British Columbia.

Maritime air masses influence both temperature and precipitation in the Nooksack-Sumas Basins, producing a mild wet climate. Approximately 75 percent of the precipitation falls during the period October through March. The recorded mean annual precipitation varies from 109 inches on Mount Baker to 32 inches at Bellingham. The average monthly temperature at Bellingham ranges from 36°F in January to 61°F in August.

Whatcom County is the leading agricultural producer of western Washington. It supports more dairy cattle than any other county in the Pacific Northwest. In this enterprise the Nooksack River floodplain plays an important part. The lower valley below Ferndale and the South Fork Valley are devoted almost entirely to pasture for dairy and beef cattle and the raising of hay crops. Between Ferndale and Lawrence, in addition to dairying, truck vegetables and berries are raised for commercial freezing and canning; the growing of seed potatoes is an increasing activity. Almost all of the potential farm land along the river has been cleared and put into production. However, upstream from Everson, a good deal of uncleared bottom land remains, particularly on the left side between Cedarville and Van Zandt, and there are still some timbered tracts on the right side.

Most of the land in the Sumas River floodplain has also been developed for uses in agriculture. Dairying is the most important agricultural enterprise and suffers less from flooding than some agricultural pursuits. Of the 1,900 acres of farmland in the United States' portion of the Sumas Valley, approximately 80 percent is in pasture and the remainder is in truck crops and berries.

In summary, agriculture on the Nooksack-Sumas floodplain probably will continue under present practices well into the future, with some dairyland being converted to vegetable crops.

2.3 Principal Flood Problems

Large, scattered areas of the Nooksack River Valley are annually subject to local flooding. The remainder of the floodplain is subject to flooding approximately once in 2 to 5 years, over areas utilized almost entirely for agriculture and containing both farm and residential buildings. Zero damage flow is considered to be approximately 19,000 cubic feet per second (cfs) at the Deming Gaging Station. When flows reach 25,000 cfs at Deming, the levees at the head of the Lummi River become vulnerable. When flows reach 35,000 cfs at Deming, the Nooksack River may overflow into the Sumas Basin upstream from Everson.

Maximum known flow was 49,300 cfs at Deming in 1932 as computed from high-water marks. At this discharge most of the floodplain is inundated. Along the South Fork and downstream near Everson, the flooded area is an irregular strip approximately 0.5 mile wide. Between the constrictions at Everson and Ferndale the flood water-surface varies from 1 to 2 miles in width, and downstream from Ferndale the delta is covered for a width of 3 to 4 miles.

In the agricultural setting of the Nooksack Valley the greater part of flood damage occurs to land and crops. This results from drowning of grasses and other plants, loss of livestock, erosion of banks and fallow ground, leaching of fertilizer, infestations by weed seed, carrying away of fences, deposition of sand, gravel and driftwood, and temporary loss of use of pasture because of ground

saturation. A special situation occurs in the delta when tidal dikes are breached by impounding river waters. The resulting salt water intrusion may reduce productivity for several years.

Next in order of importance are damages to buildings, particularly in the low portions of populated areas and to a lesser extent on farms. Damage to levees by erosion and overtopping is a significant problem, recurring as recently as December 1975. Roadways suffer erosion of embankments and shoulders, undermining of pavement, and a temporary weakening because of subgrade saturation. Restriction of travel may cause financial losses.

In the upper portions of the valley above Everson, flood damages consist chiefly of bank erosion and the deposition of sand and gravel on farm lands.

Anderson Creek enters the Nooksack River from the south several miles downstream from Lawrence. The stream drops approximately 2,700 feet in its upper 4 miles and only 200 feet in the lower 4 miles. The abrupt flattening of the gradient results in the deposition of sediment and overbank flooding.

Fishtrap and Bertrand Creeks rise in Canada and join the Nooksack River approximately 4 miles west of Lynden. Their lower floodplain is common to the floodplain of the Nooksack River. Both creeks do considerable bank cutting and much of the sediment they carry is deposited in their lower areas where they cross the Nooksack floodplain. Overbank flooding is experienced annually.

Silver Creek joins the Nooksack near its mouth north of Marietta. The creek drains an agricultural area of 9,186 acres northwest of Bellingham. In the lower 2 miles, bottomland adjacent to the Nooksack River is flooded frequently by creek overflow and occasionally by overflow of the Nooksack River. In the upper portions of the creek, large areas are subject to inundation, with damage to houses and farm buildings.

Extensive flooding of the Sumas Valley occurs when the Nooksack River overflows the low divide separating the drainage basins. The expected recurrence interval is slightly less than once in every 20 years, but may be as low as every 10 years. The exact recurrence interval is difficult to assess in the low, broad area of overflow, especially so because emergency flood-fighting measures sometimes do prevent complete overflow.

After overtopping the divide, floodwaters flow northward into Johnson Creek through a shallow swale between the Towns of Everson and Nooksack. Johnson Creek is a shallow drainage course with limited carrying capacity. Overflows from the Nooksack River cause shallow flooding of farm lands and suburban home developments in the valley containing Johnson Creek and the Sumas River.

Minor flooding occurs almost every year on the Sumas River and its tributaries, but usually is confined to low undeveloped areas.

Except for Saar Creek, tributary streams in the basin are unimproved and are characterized by shallow, winding channels that have insufficient capacity to contain storm runoff. At many locations, brush and debris in stream channels restrict the passage of floodwater and cause debris jams. In recent years, a landslide has occurred near the headwaters of Swift Creek. Glacial sediments have been removed by floodwaters from this slide, leaving masses of rocks and boulders in the streambed and upper floodplain. These sediments have formed an alluvial fan on the Sumas River floodplain and have elevated the Swift Creek Channel above the Sumas River Channel. Other streams (Dale and Breckenridge Creeks) originating on Sumas Mountain have similar slide potential.

The areas of worst flooding on the Nooksack River in the December 1975 flooding were documented by COE aerial photographs (Reference 2). Numerous areas of breaching of manmade levees and overtopping of natural and manmade levees are recorded from near Marietta, approximately 0.5 mile upstream of Bakerview Road, upstream to the backwater flooding of Kamm Ditch just east of Lynden. This is in addition to normal overbank flooding on other parts of the river. The December 1975 flood was approximately a 10-year flood at Deming, with heavy bank and levee erosion. To a great extent, the numerous breaches of levees and overtopping of banks and levees rendered the remaining flood protection structures ineffective, with floodwaters backing up behind them.

Coastal flooding problems in Puget Sound occur most frequently during the winter months when the highest tides of the year occur and are augmented by wave action. High astronomical tides combined with storm surge result in high stillwater levels. These high stillwater levels permit waves to be carried further onshore and break above normal water levels, causing additional flood hazards.

A December 1982 storm carried debris onto roads along the Birch Bay shoreline and damaged houses at both study sites. It was observed that the breakwater at the entrance to the Point Roberts Marina provided significant protection on its lee side. Observation of drift logs at both study sites indicates the narrow division between the active beach and residential property.

Houses along the south edge of Edwards Drive at Point Roberts have experienced flooding approximately every 10 to 20 years. In addition, the park northeast of the lighthouse has been subject to occasional flooding. Residents at Point Roberts recount the highest storm winds occurring from the south and typically during low tide periods.

The highest winds at Birch Bay occur from the southwest and have caused flooding of homes in the Birch Bay Village. Residents remember the golf course area being flooded during a high tide and wind event in December 1982. Debris was carried into the backshore area and over Shintaffer Road in water that was described to be approximately 1 foot deep. The lakes in the Birch Bay community

intercept interior stormwater runoff and are drained to the bay by culverts with tide gates.

2.4 Flood Protection Measures

Attempts to control the Nooksack River fall into two general categories: levees and bank stabilization. Levees have a greater influence on flood control than does bank protection. Erosion occurs at within-bank river stages as well as at overflow stages and cannot be considered entirely a flood damage. However, bank stabilization to prevent erosion has the added effect of resisting channel changes. Such changes might otherwise lengthen the river's streambed and increase its flooding tendencies. To this extent, bank stabilization can be considered a flood corrective effort.

A major consideration to land owners along the Nooksack River has been the loss of many acres of rich land through bank erosion. To reduce this loss, property owners have contributed funds along with the Agricultural Stabilization and Conservation Service, the State, and Whatcom County, toward extensive bank protection projects, using large rock, quarried and placed against the river banks by Whatcom County. In the past 6 years, the County has contributed funds to, and has done the placement work on, 87 separate bank stabilization projects. In addition, the railroads and the Highway Department have stabilized their roadbeds and bridges where they are subject to erosion. In an attempt to deflect river currents away from erosion-susceptible banks, the County has constructed timber pile training dikes and groins that tend to force the current back toward the river's center. These facilities appear to have worked well for a number of years until weakened by rot. The winter of 1950 was unusually cold, and a great deal of ice was formed on the river. When the ice broke up and flowed downstream, it smashed a number of the weakened timber groins and greatly reduced their effectiveness.

The Works Progress Administration (WPA) provided river improvements between 1935 and 1940, the bulk of the work consisting of bank protection and clearing of snags. Construction was supervised by the COE. The method of bank protection differed from current practice in that much use was made of brush mats that were lashed together and staked to freshly sloped banks. Much of this protection has rotted away. The COE has provided bank protection in locations where public property such as bridges and roads were clearly threatened with flood damage, or in conjunction with the repair of levees.

The land along both sides of the Nooksack River has been devoted primarily to agriculture since the valley was cleared. In the course of developing and protecting their property, individual residents have built levee sections along creek and river banks in the areas most subject to flooding. The potential for erosion and breaching of these dikes was demonstrated in December 1975 by flooding of approximately a 10-year recurrence interval.

The City of Everson constructed a levee along the right bank of the river from the CMSt.P&P Railroad Bridge, across the normal overflow path, to a point of high ground. This has effectively reduced the amount of Nooksack River overflow entering the Sumas River drainage basin.

The U.S. Bureau of Indian Affairs has developed a flood-control project on the Lummi Indian Reservation including levees and an intake structure at the head of the Lummi River. A dam and spillway were built across the Lummi River just below its divergence from the Nooksack. At the same time, a levee was constructed from the dam down the right bank of the Nooksack River to high ground near Marietta. The dam and spillway were washed out in 1932 and reconstructed by the Bureau of Indian Affairs. In 1950, the dam and spillway were again washed out and replaced in 1951 by the COE with a 5-foot diameter culvert through a reconstructed earth embankment.

In addition to the administration of WPA bank stabilization works and the replacement of the Lummi River head works already described, the COE made emergency repairs to existing levees at various locations during the 1940s through 1964. These were on the right bank of the river at miles 4.1, 20.7, 24.8, 25.2, and 32, and on the left bank at miles 2.8 and 3.2. In the last 10 years, numerous additional repairs have been made.

The effectiveness of these levees varies with their height, the height of the adjacent levee system of river bank, their susceptibility to erosion during periods of high water, and the effectiveness of maintenance. There are portions of the river where levees line the banks for some distance, broken only by sections of high banks whose elevations are equal to the adjoining levees. In such cases, the land behind these levees is moderately well protected until a section is overtopped or fails. In other instances, the private levees are not connected to adjoining levees or to high ground upstream or downstream. These levees are not effective in stopping inundation, but do tend to catch some debris, which would normally be deposited in the fields.

The McCauley Creek Flood Control District, one of the few flood control districts in the State, is located on the right side of the Nooksack River at Deming. Here, three creeks, Mitchell, Smith, and McCauley, flow out of the hills and across the valley floor to join the Nooksack River. These creeks were previously capable of flooding the Deming area during periods of heavy precipitation. The Flood Control District prevents flooding by maintaining a stabilized channel of sufficient capacity to carry the flow from all three creeks to the river. During emergencies, assistance is given by County personnel and equipment.

Channel improvements have also been made along 3.7 miles of Saar Creek, which is located in the eastern portion of the Sumas River Basin.

Many of the homes along the shoreline at both study sites have low, discontinuous concrete walls separating residential property from the active beach slope. These type of walls were not considered as flood protection measures because recurrence interval stillwater levels can flow behind or inundate the walls and waves can pass over them.

Flood protection for Point Roberts consists of the breakwater at the entrance to the marina, which protects the beach on its north side inside the harbor, and the Edwards Drive fill embankment, which acts as a dike and prevents high stillwater levels from entering the low backshore area.

Concrete seawalls exist at the west end of the Birch Bay study site, east of the marina entrance. It was assumed that these walls would remain in place during a 100-year event and prevent storm-induced erosion on their leeward side. During a storm event, the vertical seawalls direct the wave energy upward. This condition establishes higher base flood elevations in this area than along natural beach slopes.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail.

For the South Fork and main stem of the Nooksack River, floodflow frequency data are based on statistical analysis of stage-discharge records at gaging stations operated by the USGS (Reference 3).

This analysis follows the standard log-Pearson Type III method as outlined by the Water Resources Council (Reference 4). Gaging stations at Wickersham (on the South Fork) and at Deming, Lynden, and Ferndale were considered in these analyses.

The South Fork data utilize a 37-year period of record (1935-1971), extended to an equivalent of 40.4 years by correlation with the gaging station at Index, Washington, on the Skykomish River, and calculated by computer program L-239 (Reference 5). Data at Deming utilize a 36-year period of record (1936-1971), extended to an equivalent of 43.3 years, by the process described above. Data at Lynden are based on an adjusted rating curve of observed stages and discharges computed by routing Deming peaks to Lynden, and utilize a 22-year period of record (1946-1967), extended to an equivalent of 39 years by correlation with the primary station at Deming and the base station at Index, using computer program L-239. Data at Ferndale utilize a 5-year period of record, extended to an equivalent of 23 years, likewise by correlation with the Towns of Deming and Index, using program L-239.

Drainage area-peak discharge relationships for the main stem and South Fork, Nooksack River are described by Figure 2. The Nooksack River discharge data for the 50-, 100-, and 500-year floods are adjusted for water loss to the Sumas River in the area between Sumas and Everson. Curves between the Deming gaging station data and the point of significant overbank loss to the Sumas drainage system are based on original (unadjusted) discharge calculations. Curves downstream of that point are based on adjusted discharge data at Lynden and Ferndale and extrapolated between Lynden and the point of overbank loss. The 10-year flood does not result in loss from the Nooksack to the Sumas system.

Peak discharges for the 100-year flood on streams studied by approximate methods were determined by the method described in USGS Water-Supply Paper 1687 (Reference 3). This method considers basin area, average runoff, basin slope, climatology, area of lakes and ponds, and vegetation as independent variables for calculating the mean annual discharge. The 100-year peak discharge was calculated by multiplying the mean annual discharge by a frequency ratio factor taken from a frequency curve in the same publication.

This method was also used on the Samish River, but the results in this case are augmented by calculated overflow from the South Fork Nooksack near the Town of Saxon.

Two types of events were considered in coastal areas for independent evaluation. Flood levels were analyzed using recurrence interval stillwater elevations combined with wave runup elevations caused by winds coincident with historical stillwater elevation information. For these events, recurrence interval stillwater elevation estimates were developed from analyses of historical tide gage data combined with estimated wave runup generated by winds with the most probable magnitude and direction

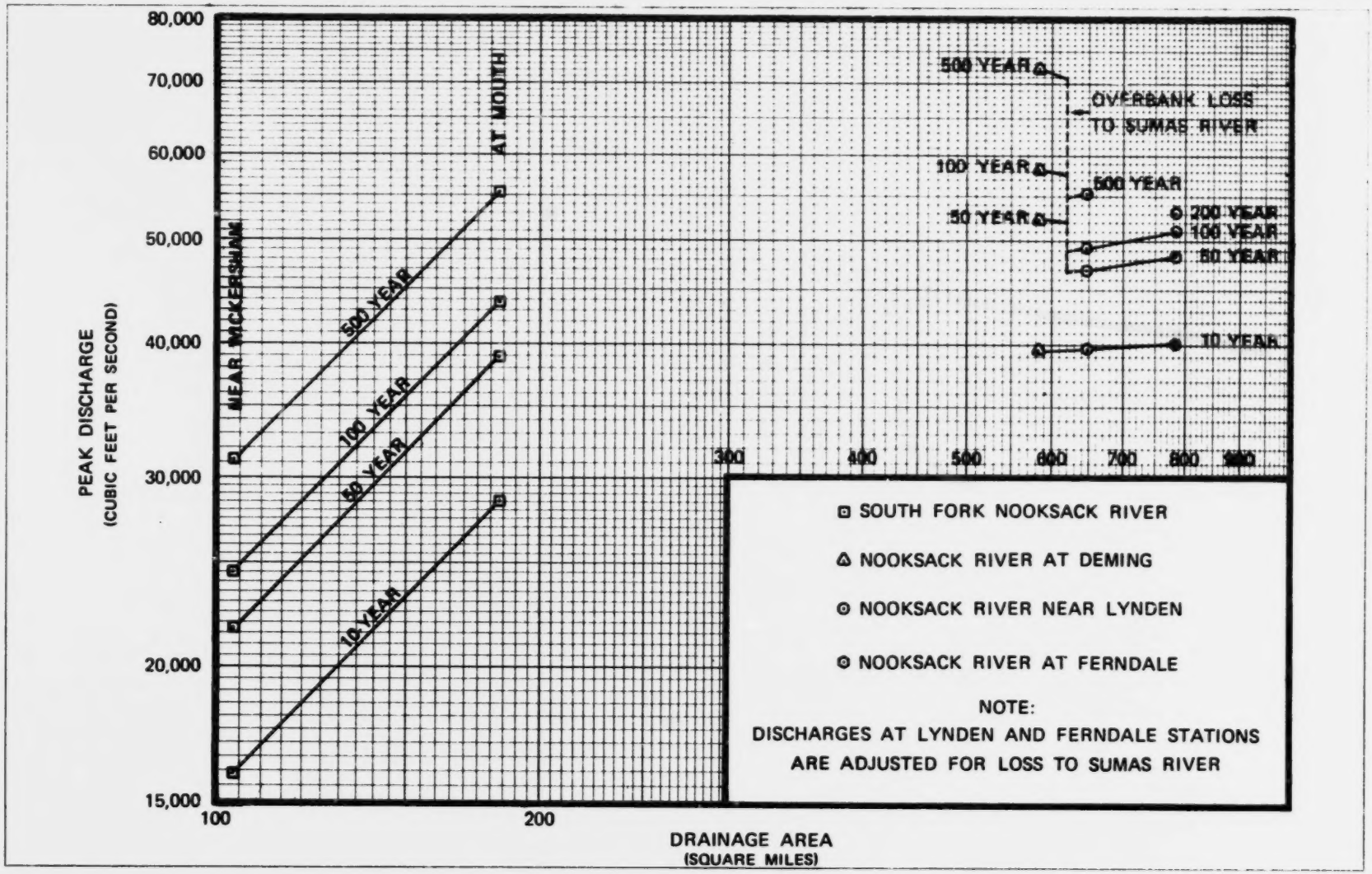


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FREQUENCY-DISCHARGE, DRAINAGE AREA CURVES

NOOKSACK RIVER, INCLUDING SOUTH FORK

class as determined from correlation analyses of historical tide and wind data.

The correlation analyses from the historical flood events indicated that extreme surface winds have not historically coincided with the maximum stillwater levels. Therefore, maximum windspeeds were analyzed to compare flood elevations from extreme wind and predicted tide conditions. These analyses considered flood levels from the statistical combinations of recurrence interval predicted astronomical tide elevations, locally generated wind setup heights, and wave runup caused by maximum-sustained recurrence interval winds.

Analyses were performed to establish peak stillwater elevation frequency relationships. Development of the recurrence interval stillwater levels for the study sites was based on an analysis of high-water elevations during the winter months (October to March) from the closest NOAA tide gage, located at Cherry Point, Washington. The short-term record at Cherry Point (1977 to 1985) was extended using linear regression of the monthly high tides at Cherry Point to the coincident monthly high tides at the nearest long-term tide gage, located at Friday Harbor, Washington (1934 to 1985). A log-Pearson Type III frequency analysis (Reference 6) was performed to determine the estimated recurrence interval stillwater elevations of the extended record. The resulting recurrence interval stillwater elevation estimates used in the study are shown in Table 1.

TABLE 1 - SUMMARY OF STILLWATER ELEVATIONS

Flooding Source and Location	Elevation (feet)			
	10-Year	50-Year	100-Year	500-Year
Strait of Georgia	7.3	7.7	7.9	8.2
Birch Bay	7.3	7.7	7.9	8.2

Windspeeds and directions coincident with the occurrences of peak stillwater elevations were taken from hourly wind data obtained from the closest long-term wind gage at Tsawwassen, British Columbia. A correlation analysis was performed to estimate the most probable wind that would occur from combined direction classes with the recurrence interval stillwater levels from the gage record. Wind data obtained from the Canadian Climatic Data Services also included summaries of monthly windspeed and frequency by direction classes. An analysis of the summaries provided probabilities of wind occurring from various directions. The combined wind direction-stillwater level frequency curve was multiplied by directional probabilities to estimate recurrence interval windspeeds for each fetch direction of interest.

Results from the analysis showed that maximum surface winds have not historically coincided with the maximum stillwater elevations.

Therefore, a second type of event was analyzed, consisting of the combined effects of astronomical high tides with locally generated wind setup and wave runup from maximum-sustained wind magnitudes. Maximum-sustained winds are windspeeds that create the maximum deepwater wave for given fetch conditions.

Stillwater elevations associated with extreme peak winds creating maximum-sustained wave conditions were based on recurrence interval astronomical tide elevations derived from a frequency analysis of the highest predicted daily tides for the winter months combined with estimated local wind setup.

Monthly windspeed versus direction summaries were obtained from a weather station close to the study sites. An analysis of the winter month data (October to March) was performed to determine the percent exceedence curve for the recorded windspeeds and to determine the recurrence interval maximum windspeeds.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the county are carried out to provide estimates of the elevations of floods of the selected recurrence intervals for each flooding source studied in detail.

For the main stem Nooksack River and the area studied in detail along the South Fork, water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE, Seattle District's computer program, which is based on Method II of the COE Engineering Manual 1110-2-1409 (Reference 7). The cross section data used in the study were 1964-65 surveyed river cross sections. The overbank or valley sections were plotted from April 1964 aerial photographs taken by Pacific Aerial Surveys, now known as Walker and Associates. These maps are included in the Nooksack River Flood Plain Information study (Reference 8). Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Boundary and Floodway Map (Exhibit 3). Channel roughness factors (Manning's "n") for these computations were assigned on the basis of new field inspections and information in 1972 and 1973.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of $\pm$ 1.0 foot for floods of the selected recurrence intervals (Exhibit 1). Stationing on Nooksack River flood profiles, including the South Fork, is referenced to the official river mile stations as revised in 1968 by the Pacific Northwest River Basins Commission.

For the Sumas Valley area, peak discharges for the 100- and 500-year floods were determined by trial and error hydraulic analysis assuming an overflow discharge, computing the Sumas Valley water-surface elevation at Emmerson Road (assumed overflow location) and comparing that elevation at Emmerson Road, based on compatible assumptions of loss of water to the Sumas Valley. Profiles for the

100- and 500-year floods were determined from a rating curve analysis using data previously developed by the COE (Reference 9). These profiles were plotted on a profile base line approximating the center of overflow in the Sumas Valley (see Exhibit 1, Panels 12P-14P, and Exhibit 3, Panels 08F, 18F, 19F, 26F, and 27F).

Elevations for the 100-year flood on the North and Middle Forks Nooksack River were developed by approximate study methods. On the North Fork just east of the Town of Glacier, the depths of the 100-year flood were taken from a study of that section of the river done by the COE (Reference 10) and incorporated onto the WCPC planning maps. Based on these depths, 100-year flood elevations were determined by extrapolation to other parts of the North and Middle Forks.

On the Samish River, a weir formula was used to estimate the discharge of the 100-year flood backwater on the South Fork Nooksack River into the headwaters of the Samish. This discharge was compared with the calculated 100-year flood on the Samish to evaluate the impact in the event of coincident 100-year flooding in the two watersheds. The minor overflow of Nooksack flooding into the Samish watershed was calculated at less than 1 percent of the 100-year flood discharge for the Upper Samish Valley, and the flood stage was consequently developed from a stage-discharge study for the Upper Samish River.

The loss of water to the Samish River would have an even less measurable effect on the South Fork Nooksack base flood elevations, so that no adjustment of the Nooksack water-surface profiles was warranted.

For streams studied by approximate hydrologic methods, "normal depth" was calculated by applying peak discharges for the 100-year flood to cross section data from topographic maps to approximate 100-year flood stages. Streams for which a normal depth calculation was used include: Dakota, Bertrand, California, Swift, Breckenridge, Terrell, Dale, Ten Mile, Deer, Anderson, Silver, Squalicum, Carpenter, Olsen, Hutchison, Austin, and Maple Creeks, Unnamed Stream A, and the Samish River. Cross section data used in these calculations was taken from USGS quadrangle maps (Reference 11).

Streams studied by approximate methods for which no significant overbank flooding was determined include Fishtrap, Chuckanut, Beaver, and Fingalson Creeks.

Hydraulic analyses that consider storm characteristics, shoreline and bathymetric characteristics of the near-shore areas, were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along the study reach shorelines.

Fetch lengths were established for the study sites based on directions of the high magnitude winds and directions of the longest open-water fetches. Waves created in deep water increase

in size in relation to open-water fetch lengths that the wind can blow across. Determination of estimated fetch lengths used in the study followed procedures described in Reference 12.

Estimates of deepwater wave heights from winds associated with the peak stillwater elevations required the estimation of an adjusted windspeed, or windstress factor, which represents the surface wind that acts on the water to form the waves. Windstress factor estimates are applied to gaged wind data. The recurrence interval extreme windspeeds were not derived from gaged wind data and, consequently, were not adjusted to windstress factors. Windstress factors were calculated using the CERC computer program MACE-5 (WIND) (Reference 13). Calculations of deepwater wave heights were performed using the CERC computer program MACE-12 (JONSWAP), incorporating methods from the COE Shore Protection Manual (Reference 14).

Because of shorter open-water fetch lengths available for wave development, the inland sheltered waters of Puget Sound are subject to lower wave heights than the open coast. Maximum waves in Puget Sound are therefore generally fetch limited and occur at a duration coinciding with the earliest occurrence of a fetch-limited wave condition. This condition was determined using graphical methods presented in Reference 15.

The computer program WAVES2 (Reference 16) was used to estimate refraction and shoaling effects of incoming deepwater, fetch-limited waves as they approached the study sites. Wave ray locations and directions were established on a two-dimensional depth grid that encompassed the area adjacent to the study reach shorelines.

Wave heights and runup were estimated from the refracted deepwater waves at transects (cross section lines) located within the study limits, as illustrated in Figures 3 and 4. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced closely together in areas of changing topography and dense development. In areas having more uniform characteristics, they were spaced at large intervals. It was also necessary to locate transects in areas where unique flooding conditions existed and in areas where wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended inland to a point beyond probable wave action. The stillwater elevations for the 100-year flood were used as the starting elevations for wave runup computations. Estimated wave runup heights were calculated to the nearest 0.1 foot, and base flood elevations were determined at whole-foot increments along the transects. A location on each transect at 3 feet below the runup wave height elevation was used for determining the terminus of the V1 Zone (area with velocity wave action). The A1 zone extends landward from the V1 zone to the point where the 100-year

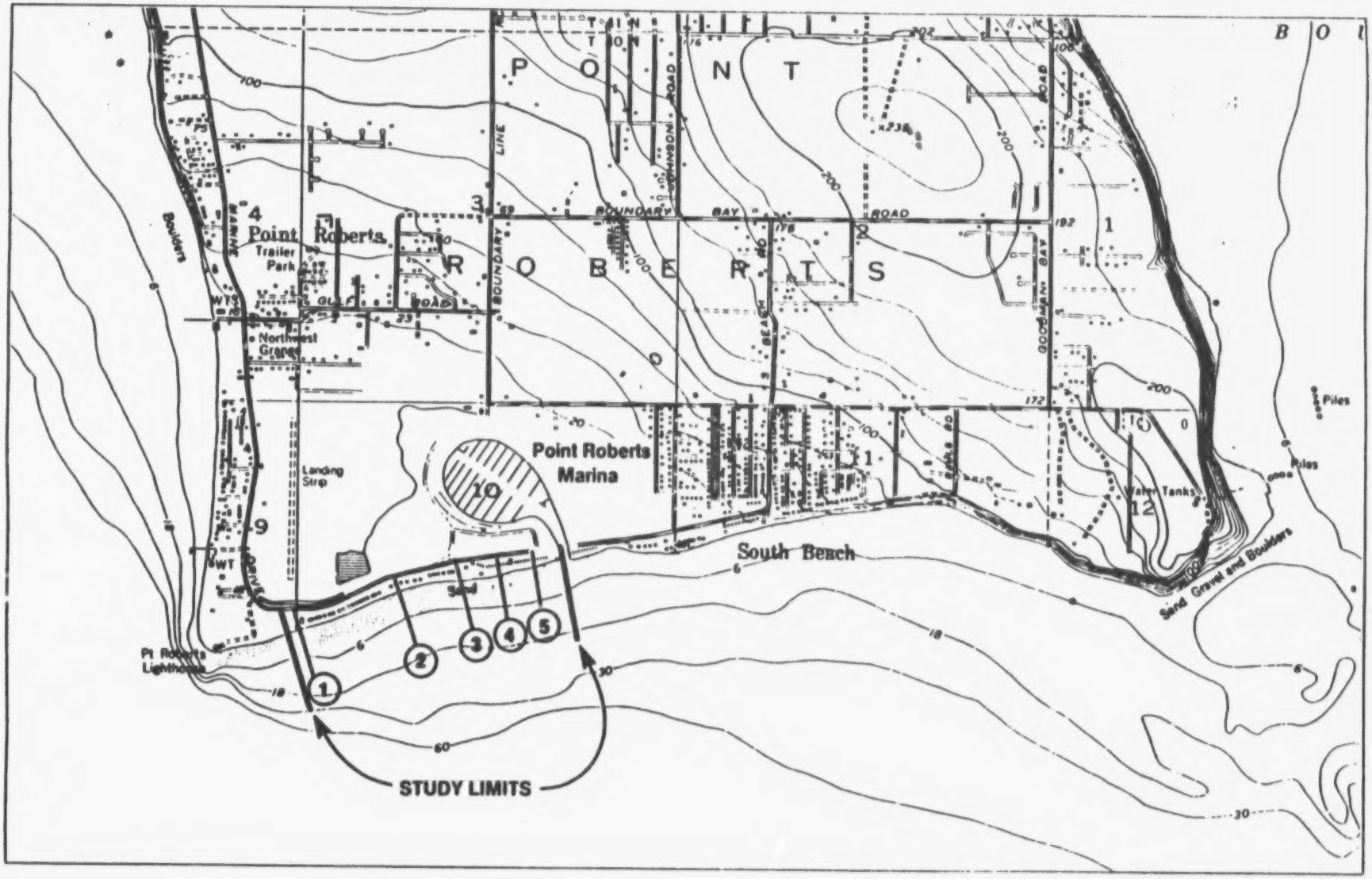


FIGURE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WASHINGTON
(UNICORPORATED AREAS)

APPROXIMATE SCALE

2000 0 2000 4000 6000 Feet

19 TRANSECT LOCATION MAP: POINT ROBERTS

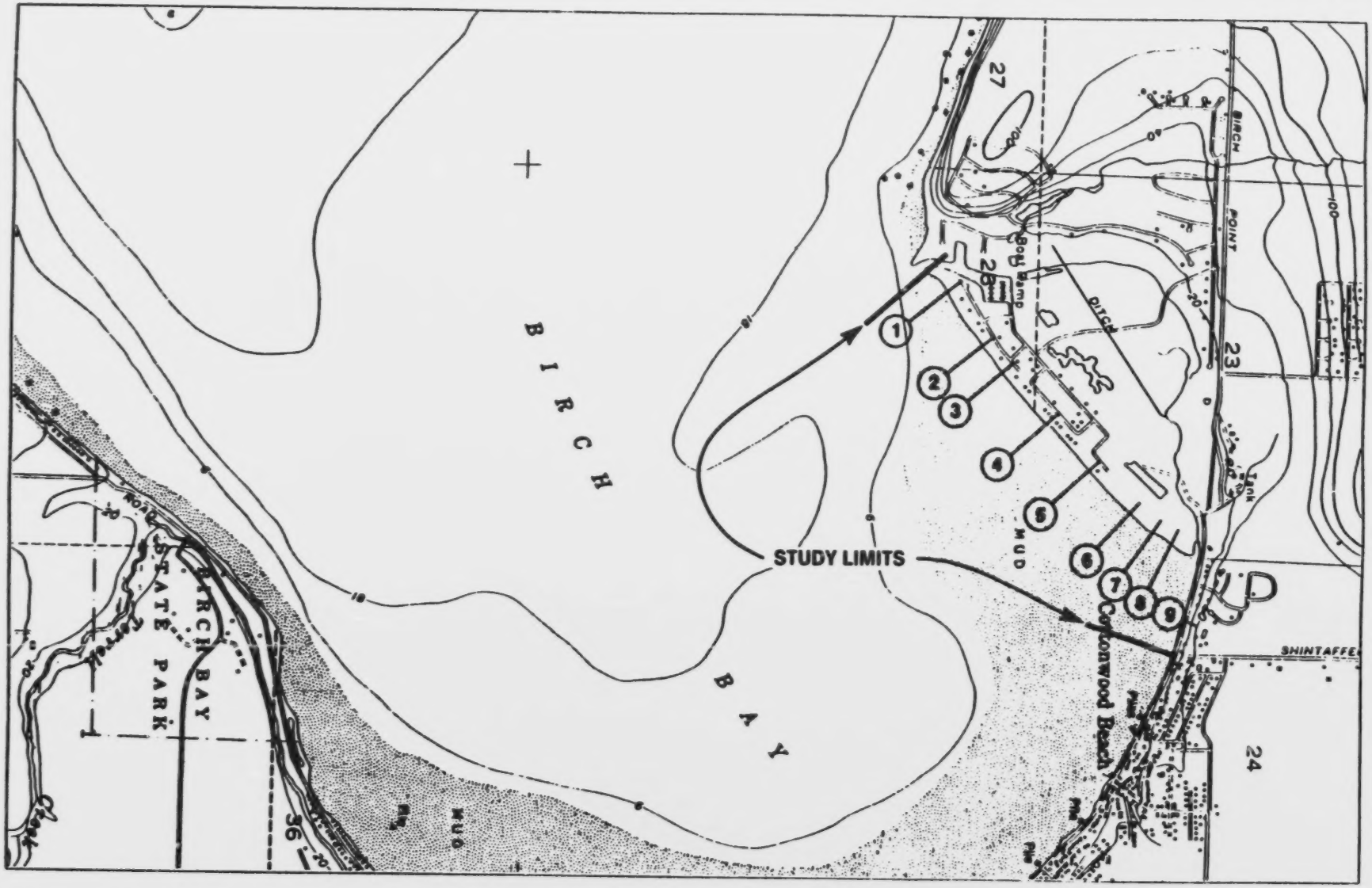


FIGURE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WASHINGTON
(UNICORPORATED AREAS)

APPROXIMATE SCALE

2000 0 2000 4000 6000 Feet

TRANSECT LOCATION MAP: BIRCH BAY

stillwater elevation intersects land. Tables 2 and 3 provide a listing of the transect locations and stillwater starting elevations, as well as base flood elevations.

Table 2
POINT ROBERTS TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet NGVD) Stillwater 100-year	Elevation (feet NGVD) Base Flood Elevation 100-year
1	At the east boundary of the county park from Edwards Drive extended south	7.9	11
2	Approximately 1,500 feet east of Transect 1, from Edwards Drive extended south	7.9	11
3	Approximately 900 feet east of Transect 2, from Edwards Drive extended south	7.9	11
4	Approximately 950 feet west of the west bank of the Marina entrance, from Edwards Drive extended south	7.9	11
5	Approximately 400 feet west of the west bank of the Marina entrance, from Edwards Drive extended south	7.9	11

Table 3
BIRCH BAY TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet NGVD) Stillwater 100-year	Elevation (feet NGVD) Base Flood Elevation 100-year
1	At the southwest cul-de-sac of Haida Way, from Haida Way extended southeast	7.9	14
2	Approximately 300 feet northeast of the intersection of Haida Way and Nitivat Way, from Haida Way extended southeast	7.9	14

Table 3
BIRCH BAY TRANSECT DESCRIPTIONS (Cont'd)

Transect	Location	Elevation (feet NGVD) Stillwater 100-year	Elevation (feet NGVD) Base Flood Elevation 100-year
3	Approximately 150 feet southwest of the northeast cul-de-sac on Haida Way, from Haida Way extended southeast	7.9	13
4	Approximately 400 feet southwest of the northeast corner of Tsawwassen Loop, from Tsawwassen Loop extended southeast	7.9	10
5	Approximately 50 feet northeast of the southern most corner of Nootka Loop, from Nootka Loop extended southeast	7.9	10
6	Approximately 830 feet northeast of Transect 5, from Nootka Loop extended southeast	7.9	10
7	Approximately 410 feet northeast of Transect 6, from Nootka Loop extended southeast	7.9	13
8	Approximately 300 feet northeast of Transect 7, from the south cut bank of the slough extended southeast	7.9	11
9	Approximately 500 feet west of Shintaffer Road, from the base of the hill north of Birch Point Road extended south	7.9	9

Beach characteristics were obtained from the surveyed beach transects. The angle of the seaward beach slopes and the heights of seawalls or berms were measured from plotted survey data. Stillwater levels were used to determine the depth of water at the toe of structures.

Runup analysis procedures were based on empirical studies that included the effects of wave setup (References 17 and 18). Flood elevations for the most probable flood event were obtained by adding the recurrence interval runup estimate to the appropriate predicted recurrence interval stillwater elevation. Statistical combinations of recurrence interval maximum-sustained wind setup

and wave runup with recurrence interval astronomical tide heights were performed to determine flood elevations for the extreme flood event. The event producing the higher flood elevation was used to establish the base flood elevation. Estimation of runup heights was based on knowledge of the transects from site visits, understanding of the strengths and limitations of the runup procedures, and engineering judgment.

Elevations used in this study are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. Elevation reference marks used are shown on the Flood Insurance Rate Map.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study produces flood boundary maps designed to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management measures. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each flooding source studied in detail, the boundaries of the 100- and 500-year flood have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000, with contour intervals ranging from 20 feet to 10 or 5 feet in less steep areas. On South Fork Nooksack River, south of Strand Road, the topographic map used was photo-enlarged to 1:24,000 from an original scale of 1:62,500, with 50-foot contour intervals. For

the Sumas Valley area, contour maps (Reference 9), with contour intervals of 5 feet and spot elevations to the nearest 0.1 foot, were used in conjunction with USGS quadrangle maps to delineate 100- and 500-year flood boundaries in accordance with elevations developed on the Sumas Valley Flood Profiles. Sheetflooding areas within the limits of inundation were determined by plotting the differences in elevation between the 100-year flood water-surface and the average ground-surface elevations. For each coastal area studied in detail, the 100- and 500-year flood elevation boundaries have been delineated using the flood elevations determined at each transect. Between transects the boundaries were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet.

For streams studied by approximate methods, the boundary of the 100-year flood was estimated using the elevations determined by

normal depth calculations and applying these elevations to the topographic maps referenced above.

The flood boundaries for Saar Creek were taken from the Flood Plain Information study (Reference 9) previously prepared by the COE.

On sizeable ponds and lakes, the 100-year flood boundaries have been delineated. These boundaries should be regarded as applying to the present boundaries of these areas of permanent standing water; they were not determined by detailed nor approximate study methods.

For the North and Middle Forks Nooksack River, the flooding depths determined in the approximate study (based on flood profiles near the Town of Glacier) were extrapolated to other parts of the North and Middle Forks and flood boundaries estimated by applying the corresponding elevations to County planning maps. These maps were composed with consideration to information supplied by local residents from their first-hand experience with the 1951 flood, and with reference to aerial photographs of the river and 10-foot interval contour maps supplied by the COE. The 1951 flood was a 12-year frequency flood, but for purposes of boundary delineation is considered nearly coincident with the 100-year flood in the extensive lengths of steep banks in this area. Finally, these flood boundaries were plotted on Flood Boundary and Floodway Maps (Exhibit 3) with adjustments according to the latest available USGS topographic information.

On the Samish River, the base flood elevations determined in the stage-discharge study were correlated with available topographic information to determine the 100-year flood boundaries in the upper Samish Valley.

Floodplain boundaries are indicated on the Flood Insurance Rate Maps (Exhibit 1). On these maps, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A1 and V1); and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards (Zone B).

Flood boundaries for coastal areas studied by approximate methods were delineated according to topographic contour information on USGS topographic quadrangle maps (Reference 11). COE unpublished information indicates an approximate elevation of 12 feet for 100-year coastal flooding with wave runup. This elevation was used in coastal areas in Whatcom County where approximate methods were employed.

In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown because of limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on floodplains, such as artificial fill, reduces flood-carrying capacity, and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program (NFIP), the concept of a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year flood is divided into a proposed floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood be carried without substantial increases in flood heights. Criteria adopted by FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced.

Due to the meandering nature of the Nooksack River, the floodways presented in this study were not determined using the equal conveyance reduction method, but were initially selected using applied principles of open channel hydraulics. The effect of these floodways on the base flood elevation were computed to ensure that there would be no violation of FEMA policy limiting the surcharge to 1 foot. The results of these computations are tabulated at cross sections in Table 4. These floodways were presented to the WCPC for their review and comments. At their request, greater restrictions were placed on the determination of floodways to ensure that certain land within the floodplain of the Nooksack and contiguous floodplain areas of major tributaries would remain as agricultural land. Floodway limits were relocated accordingly.

In Table 4, the width listed for "Proposed Floodway" at each cross section refers to the measurement between the floodway limits as finally located; the width listed for "Computed Floodway" refers to the wetted perimeter dimensions of original computations made to determine the amount of surcharge produced by the preliminary floodway boundaries. Wetted perimeter values have been considered equivalent to widths for the requirements of Table 4.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 5.

The floodway concept was not used for the floodplain of the Nooksack River downstream of Ferndale nor for the Sumas Valley because of the unpredictable nature of the main channel of flow for these areas.

FLOODING SOURCE		PROPOSED FLOODWAY	COMPUTED FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	STATION[1]	WIDTH (FEET)	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY (MSI)	WITHOUT FLOODWAY (MSI)	DIFFERENCE (Ft.)
Nooksack River								
A	8.65	3,155	3,151	22,867	2.2	33.0	33.0	0.0
B	10.68	3,000	3,758	22,929	2.2	35.1	35.0	0.1
C	14.08	4,300	3,590	15,089	3.3	43.4	43.2	0.2
D	15.30	4,870	348	6,843	7.2	47.6	47.4	0.2
E	16.35	4,800	3,211	14,738	1.7	50.1	49.8	0.3
F	18.00	4,500	3,887	15,830	1.2	56.7	55.7	1.0
G	19.31	5,500[2]	5,424	25,275	0.7	62.2	61.3	0.9
H	20.70	4,620	4,559	18,673	2.7	68.2	67.3	0.9
I	21.75	4,900	5,009	36,583	1.4	74.7	74.5	0.2
J	22.88	2,680	2,517	10,467	4.9	78.4	78.3	0.1
K	25.00	6,320	2,441	15,857	3.3	93.6	93.6	0.0
L	26.10	2,700	2,053	11,330	5.3	102.4	102.4	0.0
M	26.92	3,300	3,085	19,326	3.1	112.9	112.9	0.0
N	28.05	4,800	3,825	10,760	5.6	122.5	122.4	0.1
O	29.58	2,230	2,198	13,538	4.3	135.2	135.2	0.0
P	30.30	3,130	2,022	14,396	4.1	146.8	146.6	0.2
Q	30.90	2,600[3]	431	4,743	12.4	156.1	156.1	0.0
R	32.00	4,170	3,102	14,639	4.0	169.7	169.7	0.0
S	33.30	2,040	1,079	7,184	8.2	180.2	180.2	0.0
T	34.45	1,900	1,884	15,361	3.8	195.6	195.6	0.0
U	35.40	2,000	1,480	10,243	5.7	209.5	209.5	0.0
V	36.50	750	611	7,050	8.3	224.6	224.6	0.0

[1]Miles Above Mouth
[2]Does Not Include Floodway for Spring Creek Backwater
[3]As Measured Just Downstream of Bridge; Channel Under Bridge is 431 Feet

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINCORPORATED AREAS)

FLOODWAY DATA

NOOKSACK RIVER

FLOODING SOURCE		PROPOSED FLOODWAY	COMPUTED FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	STATION[1]	WIDTH (FEET)	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY (MSL)	WITHOUT FLOODWAY (MSL)	DIFFERENCE (FT)
South Fork Nooksack River								
A	0.50	990	655	5,949	7.4	229.1	229.1	0.0
B	1.30	1,930	1,809	13,276	3.2	234.6	234.6	0.0
C	1.80	2,460	2,271	8,728	4.7	237.3	237.3	0.0
D	2.93	1,750	1,889	12,091	3.3	243.4	243.0	0.4
E	4.90	3,880	3,744	8,468	4.5	257.3	256.7	0.6
F	5.45	4,050	3,598	11,540	3.2	262.5	262.5	0.0
G	6.95	1,080	1,009	5,679	6.1	272.8	272.8	0.0
H	7.90	620	738	5,516	6.1	285.2	285.1	0.1
I	8.80	920	649	4,483	7.1	296.5	296.1	0.4
J	9.47	1,940	1,081	4,570	6.7	308.4	308.4	0.0
K	10.15	1,180	841	4,912	5.9	320.0	320.0	0.0
L	11.65	1,720	1,206	4,262	6.4	342.5	342.5	0.0
M	13.05	580	480	3,157	8.2	363.5	363.5	0.0
N	14.20	440	337	2,519	9.7	384.2	384.3	-0.1

[1]Miles Above Mouth

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINCORPORATED AREAS)

FLOODWAY DATA

SOUTH FORK NOOKSACK RIVER

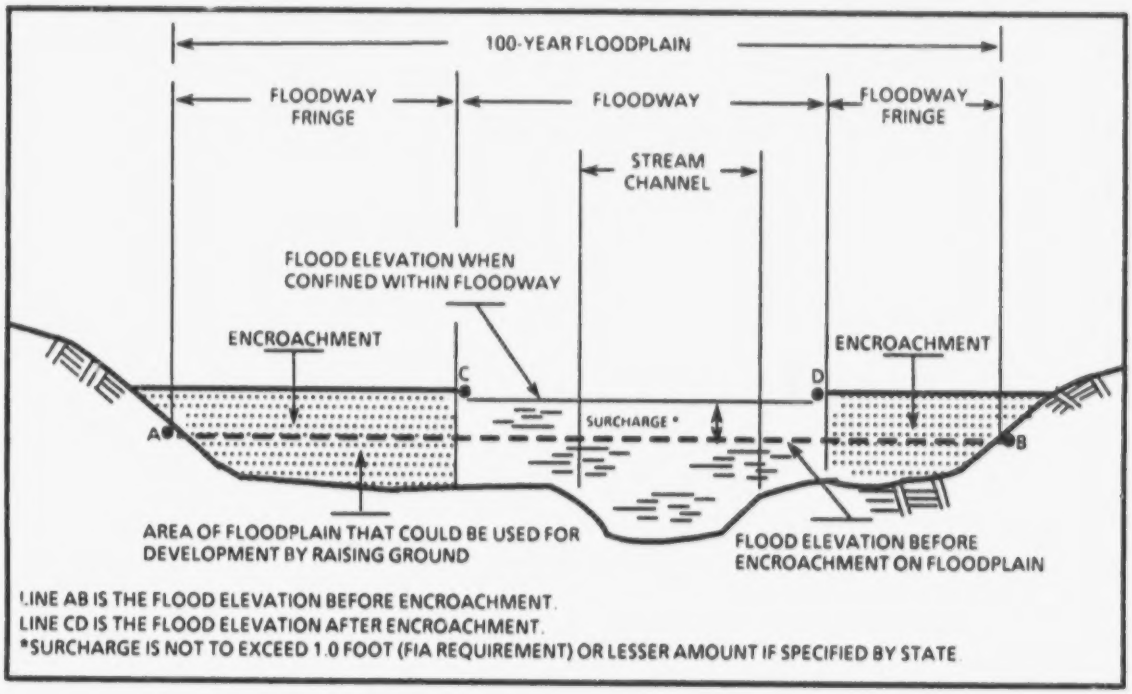

100-YEAR FLOODPLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
A
B
SURCHARGE *
AREA OF FLOODPLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOODPLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

Figure 5. Floodway Schematic

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source affecting Whatcom County.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet

Special consideration was given to the determination of reaches for the Sumas Valley floodplain. Overflow into the Sumas Valley from the Nooksack River at Everson occurs when the Nooksack River is at slightly less than a 20-year frequency floodflow, but greater than a 10-year frequency floodflow. Therefore, the 10-year flood elevation could not be used in computations. FEMA authorized use of the average weighted difference between the 100-year flood elevation and the ground elevation to establish reaches for the Sumas Valley. The Sumas Valley Supplement, Flood Plain Information study (Reference 9) and USGS quadrangle maps (Reference 11) were used to establish the best available topographic data for calculation of differences in elevation from the 100-year flood surface.

Six reaches were required for the flooding sources of Whatcom County studied in detail. These included three on the Nooksack River from its mouth to the mouth of the South Fork, one on the South Fork Nooksack River from its mouth to Skookum Creek, and two for the Sumas Valley from the City of Everson to the City of Sumas. The location of these reaches are shown on the Flood Profiles, Exhibit 1.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is FEMA's device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire unincorporated area of Whatcom County was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations or FHFs determined.

Zone V: Special Flood Hazard Areas along coasts inundated by the 100-year flood, as

determined by approximate methods, and that have additional hazards due to velocity (wave action); no base flood elevations shown nor FHFs determined.

Zone AO: Special Flood Hazard Areas inundated by types of shallow flooding where depths are between 1.0 and 3.0 feet and the product of the depth (in feet) and velocity (in feet per second) is less than 15; no FHFs determined.

Zones A1, A3, A4, A5, A6, A8: Special Flood Hazard Areas inundated by the 100-year flood with base flood elevations determined and zone designations assigned according to the FHF.

Zone 1: Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.

Zone B: Special Flood Hazard Areas inundated by types of shallow flooding where depths are 1.0 foot or less and the product of the depth (in feet) and the velocity (in feet per second) is less than 15; no FHFs determined. Also, areas between A1, A3, A4, A5, A6, A8, and the limits of the 500-year flood.

Zone C: Area not subject to flooding by the 500-year flood.

Table 5, Flood Insurance Zone Data, summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Whatcom County is, for insurance purposes, the net result of the Flood Insurance Study. Published separately, as part of this study, it is the official map on which FEMA has delineated the flood insurance zones and base flood elevation lines. Base flood elevation lines show locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100 - YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10 - YEAR)	2% (50 - YEAR)	0.2% (500 - YEAR)			
Nooksack River							
Reach 1	40	-0.2	--	0.1	005	A1	Varies
Reach 2	17,18,24,25, 26,27,32,33, 34,35,40	-1.5	--	0.8	015	A3	Varies
Reach 3	35,36,43,44	-2.3	--	1.2	025	A5	Varies
South Fork Nooksack River							
Reach 1	44,52,60,68	-2.0	--	1.1	020	A4	Varies
Sumas Valley							
Reach 1	08	-4.1	--	1.5	040	A8	Varies
Reach 2	18,19	-3.2	--	0.9	030	A6	Varies
Sheet Flow Area	08,18,19,26,27					A0	Varies
Strait of Georgia							
Reach 1	12	-0.6	-0.2	0.3	006	V1	11 Feet
Birch Bay							
Reach 1	15	-0.6	-0.2	0.3	006	V1	9 to 14 Feet

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot [4] 50-Year Flood Not Developed

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

NOOKSACK RIVER, SOUTH FORK NOOKSACK RIVER, SUMAS VALLEY, STRAIGHT OF GEORGIA, BIRCH BAY

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100 - YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10 - YEAR)	2% (50 - YEAR)	0.2% (500 - YEAR)			
Alvernon Wash Shallow Flooding	1645	N/A	N/A	N/A	N/A	AH	Elevation Varies See Map
Alamo Wash Shallow Flooding	1645	N/A	N/A	N/A	N/A	AH	Elevation Varies See Map
Robb Wash Shallow Flooding	1665, 1670 2260	N/A	N/A	N/A	N/A	AH	Elevation Varies See Map

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

PIMA COUNTY, AZ
(UNICORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

ALVERNON WASH-ALAMO WASH-ROBB WASH

6.0 OTHER STUDIES

The Nooksack River was previously studied by the COE, Seattle District, and reported January 1964 in a Flood Plain Information study (Reference 8). The present Flood Insurance Study has utilized the same cross section data for development of the flood profiles, but the present profiles were computed by a more recently developed backwater computation routine (multiple portion) and are considered to be more reliable than those shown in the Flood Plain Information study.

The Sumas River was studied previously by the COE, Seattle District, and reported May 1967 in the Sumas River Supplement to the Nooksack River Flood Plain Information study (Reference 9). The flood profiles in the present study were determined from a rating curve analysis using data developed for the Sumas River Supplement. The profiles of the two studies are complementary and consistent, although developed along different ground lines and for different frequency floods.

The Pacific Northwest River Basins Commission's, Comprehensive Study of Water and Related Land Resources, Appendix XII, Flood Control, gives background and history of flooding in Whatcom County and makes planning projections and recommendations for flood-control measures (Reference 19).

The profile of the 100-year flood for a section of the North Fork Nooksack River was determined recently in connection with planned land development in that area (Reference 10). Data from that study were utilized in this report and are compatible with it.

There are no comparable flood elevation studies available for incorporated areas within Whatcom County or for contiguous areas and communities. Flood profile data in this study supersede earlier COE Flood Plain Information studies. This report is authoritative for purposes of the NFIP.

Similar studies relating to coastal flooding in unincorporated areas of Whatcom County have been prepared previously. The COE, Seattle District, prepared a draft coastal flooding study for Whatcom County in June 1977. The study included sites at Point Roberts along the southeast headland and at Birch Bay from Birch Bay State Park north to Cottonwood Beach. In this study, the 100-year tidal flood levels for most of the Point Roberts reaches coincide well with those determined in the COE study. The 100-year flood levels from the COE study for Birch Bay tend to increase in a northerly direction from Birch Bay State Park as the reach becomes more exposed to winds from the southwest. Flood levels for this study coincide with the 9.0 feet NGVD level in the vicinity of Cottonwood Beach determined in the COE study. Progressively higher flood levels occur from the study boundary southwest of Cottonwood Beach because waves are transported farther to shore as the mud flats recede and the shoreline becomes more exposed to wind waves. The high flood elevations in Reach 1 of this study for Birch Bay are caused by vertical seawalls, which direct wave energy upward. Wind and tide data were reviewed from the design of the Point Roberts Marina (Reference 20).

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Chief, Natural and Technological Hazards Division, FEMA, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98021-9796, or the County Engineer's Office, 311 Grand Avenue, Bellingham, Washington 98225.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Department of Commerce, Bureau of the Census, 1980 Census of Population, Number of Inhabitants, Washington, 1981.

2. U.S. Department of the Army, Corps of Engineers, Seattle District, Aerial Photo Maps: Nooksack River Flood, S75058, photographed December 4, 1975.

3. U.S. Department of the Interior, Geological Survey, Water-Supply Paper 1687, Magnitude and Frequency of Floods in the United States, Part 12, Pacific Slope Basins in Washington and Upper Columbia River Basin, J.L. Bodhaine and D.M. Thomas, 1964.

4. U.S. Water Resources Council, "A Uniform Technique for Determining Flood Flow Frequencies," Bulletin 15, December 1962.

5. U.S. Department of the Army, Corps of Engineers, Seattle District, EM 1110-2-1409, Backwater Computations, Method II, April 20, 1973; Hydraulic Floodway Analysis, May 9, 1973; Computer Program, L-239, Cumulative Frequency Curve of Maximum Annual Peak Rain Flood Discharge, January 1973.

6. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, Computer Program, 723-X6-L7550, Flood Flow Frequency Analysis, June 1976.

7. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, EM 1110-2-1409, Backwater Curves in River Channels, December 7, 1959.

8. U.S. Department of the Army, Corps of Engineers, Seattle District, Flood Plain Information, Nooksack River,Washington, January 1964.

9. U.S. Department of the Army, Corps of Engineers, Seattle District, Sumas River Supplement, Flood Plain Information, Nooksack River, Washington, May 1967.

10. U.S. Department of the Army, Corps of Engineers, Seattle District, North Fork Nooksack River, Near Glacier, Washington, unpublished study, March 28, 1975.

11. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps: Point Roberts, Birch Point, Blaine, Bertrand Creek, Lynden, Lummi Bay, Lake Whatcom, Van Zandt, and Anacortes, Washington; 15-Minute Series Topographic Maps: Wickersham, Washington.

12. U.S. Department of the Army, Corps of Engineers, Coastal Engineering Research Center, Shore Protection Manual, 4th Edition, 1984.

13. U.S. Department of the Army, Corps of Engineers, Coastal Engineering Research Center, Computer Program, WIND (MACE-5) Adjusted Windspeed for Wave Forecasting, Vicksburg, Mississippi, December 1985.

14. U.S. Department of the Army, Corps of Engineers, Coastal Engineering Research Center, Computer Program, JONSWAP (MACE-5) Deep Water Wave Forecasting, Vicksburg, Mississippi, December 1985.

15. U.S. Department of the Army, Corps of Engineers, Engineering Technical Letter 1110-2-305, Determining Sheltered Water Wave Characteristics, C.L. Vincent and J.H. Lockhart, February 1984.

16. R.S. Dobson, Technical Report No. 70, Some Applications of a Digital Computer to Hydraulic Engineering Problems, Stanford: Stanford University Press, 1967.

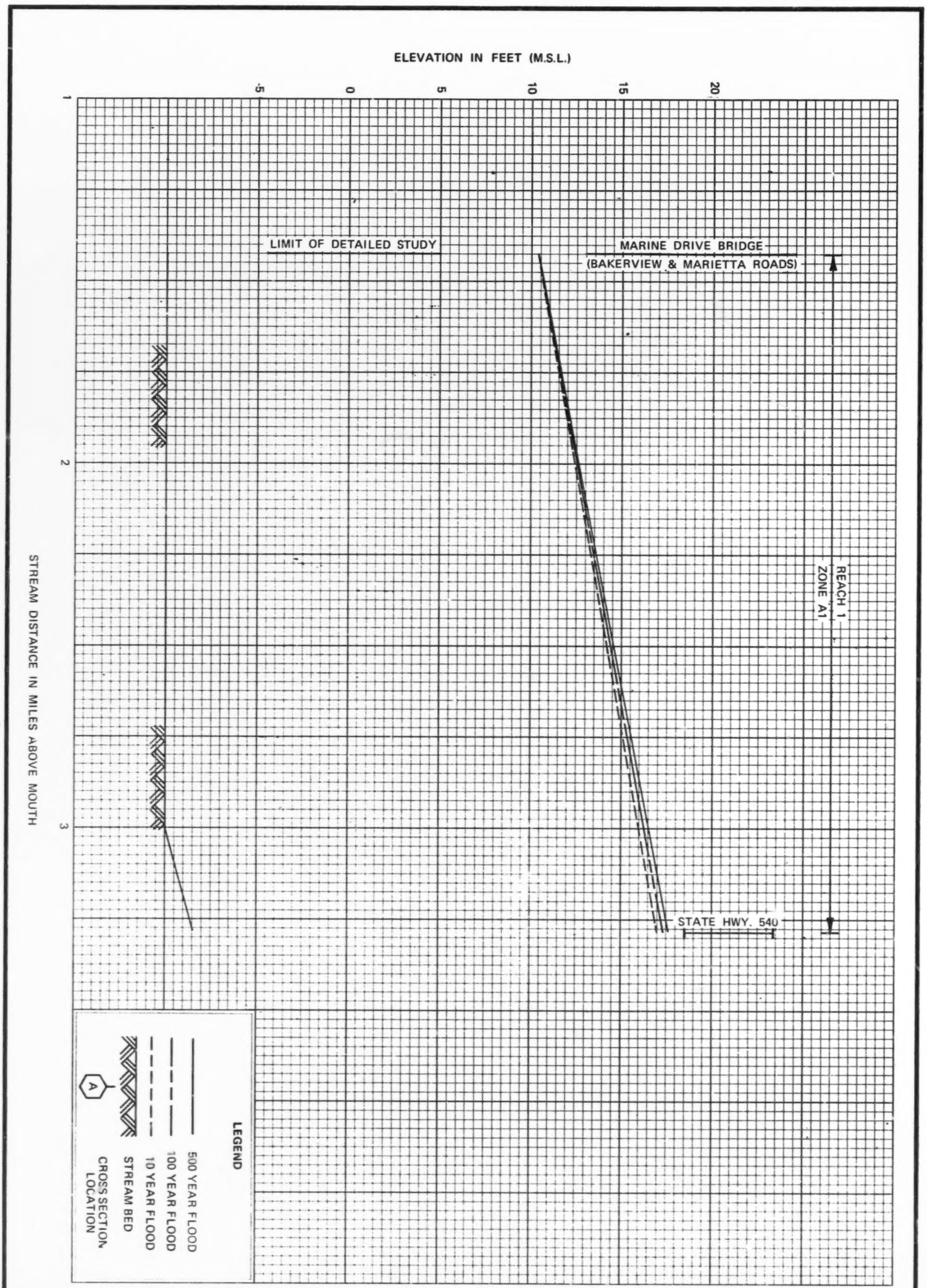
17. U.S. Department of the Navy, Naval Facilities Engineering Command, Coastal Protection Design Manual 26.2, April 1982.

18. CH2M HILL Northwest, Inc., Design Project Notes (S9568. F1), "Point Roberts Marina: Breakwater/Jetty," Bellevue, Washington, March 1982.

19. Puget Sound Task Force-Pacific Northwest River Basins Commission, Comprehensive Study of Water and Related Land Resources, Puget Sound and Adjacent Waters, State of Washington, Appendix XII, Flood Control, March 1970.

20. J. Downing, The Coast of Puget Sound: Its Processes and Development, Seattle: Puget Sound Books, 1983.

U.S. Department of the Interior, Geological Survey, Open-File Report 74-336, Magnitude and Frequency of Floods in Washington, J.E. Cummans, M.R. Collings, and E.G. Nassar, Tacoma, Washington, 1975.



FEDERAL EMERGENCY MANAGEMENT AGENCY

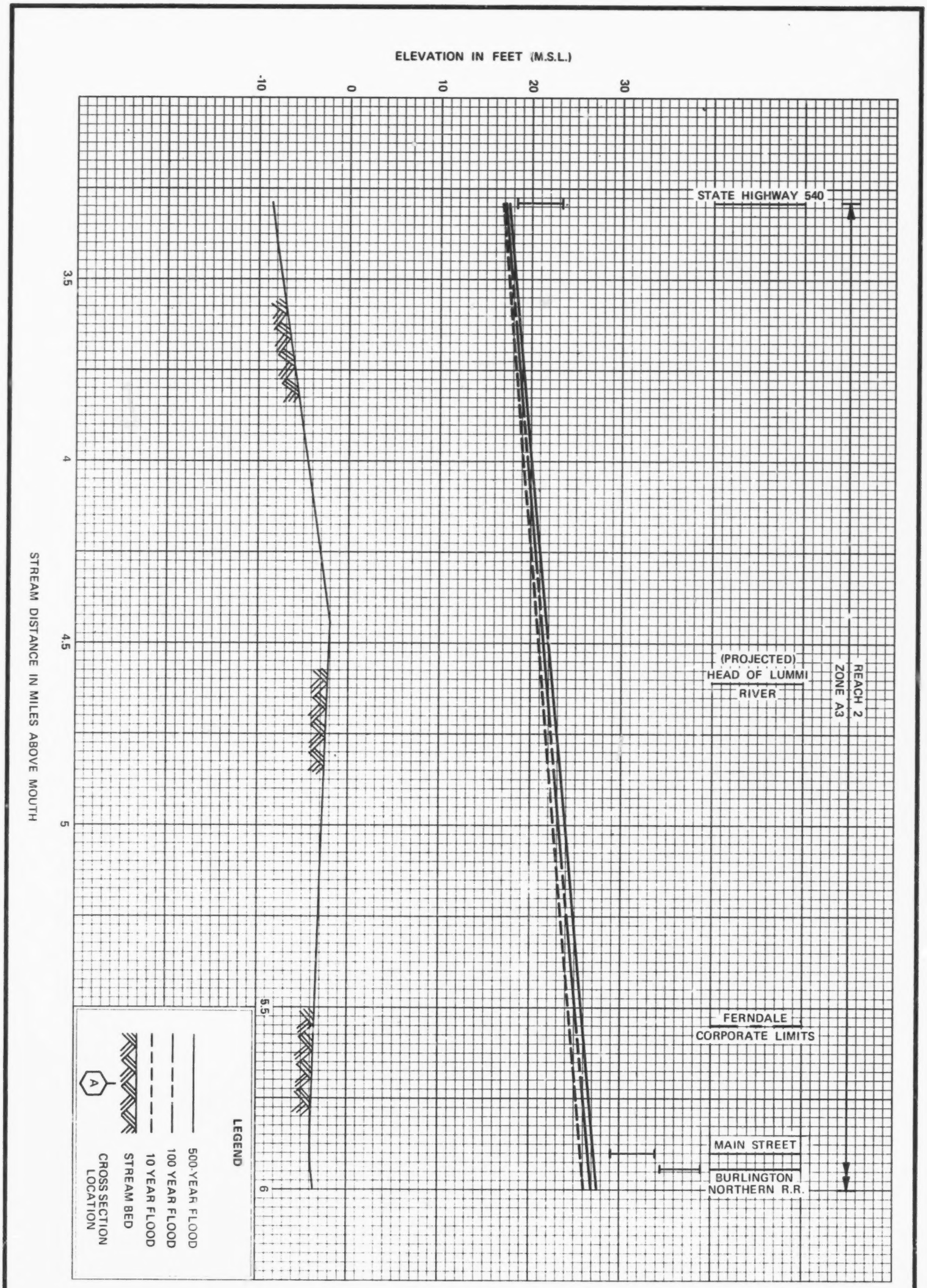
WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

NOOKSACK RIVER

01P

EXHIBIT 1



FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

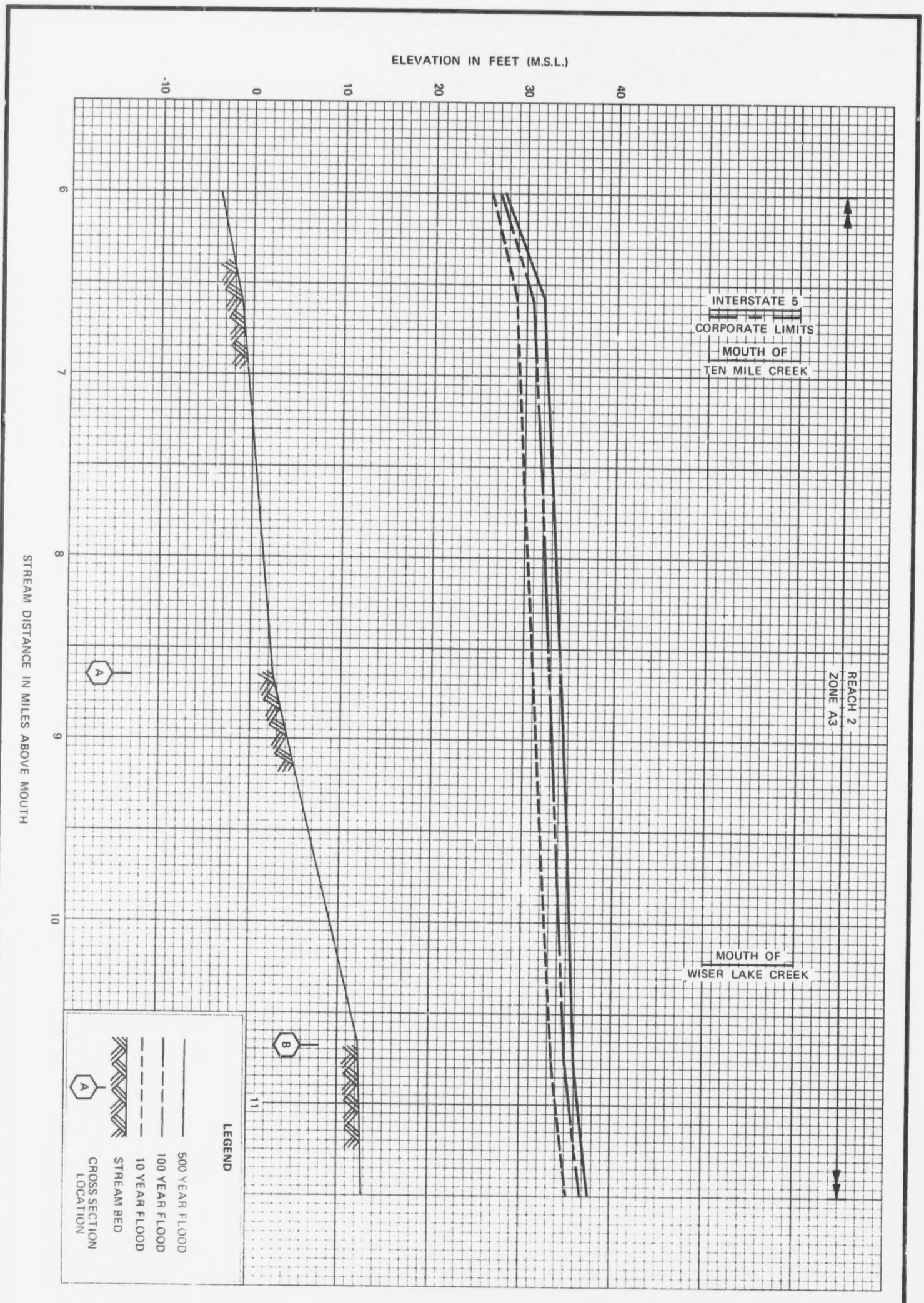
FLOOD PROFILES

NOOKSACK RIVER

02P

EXHIBIT 1

37



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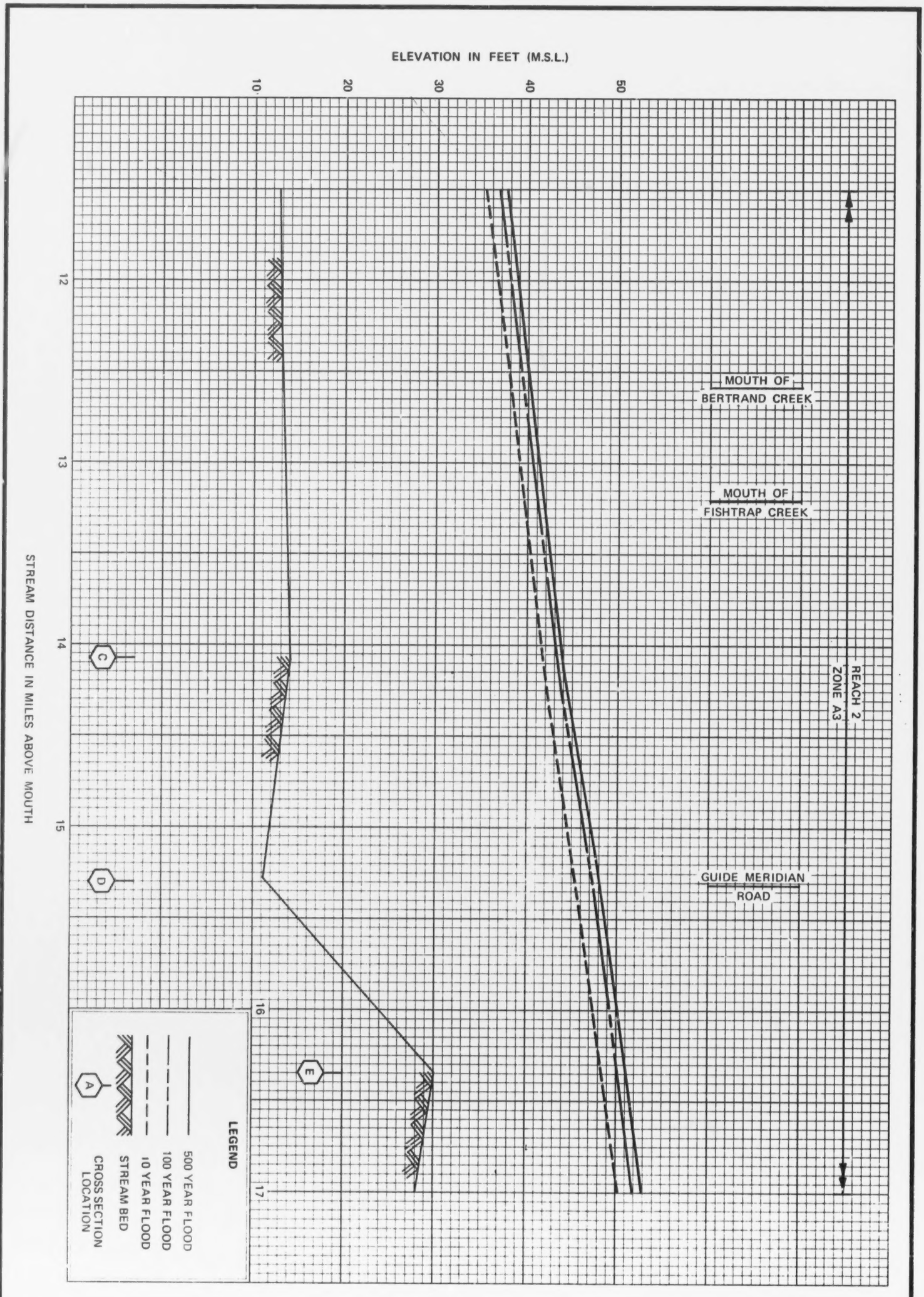

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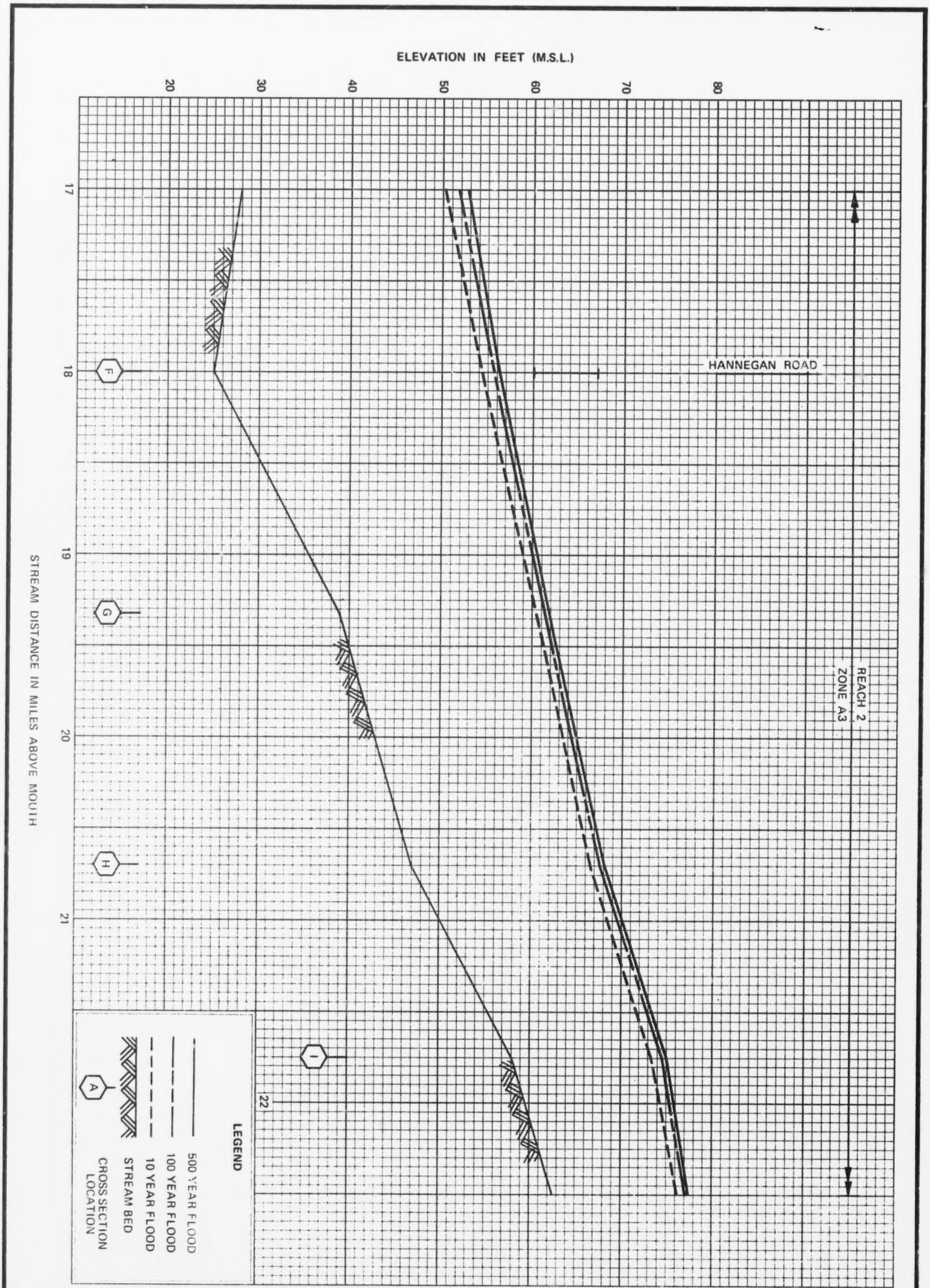


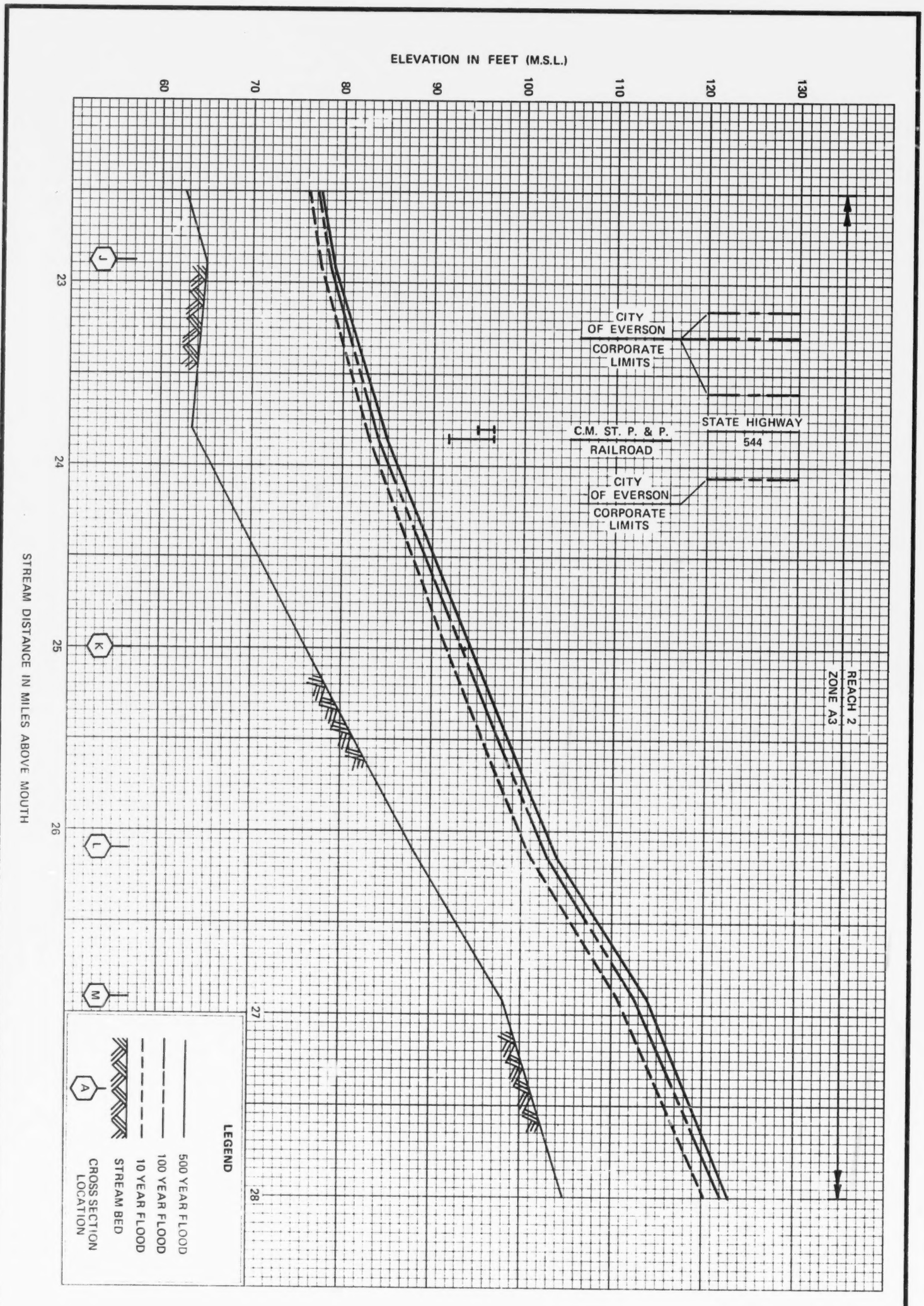
FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

NOOKSACK RIVER

05P



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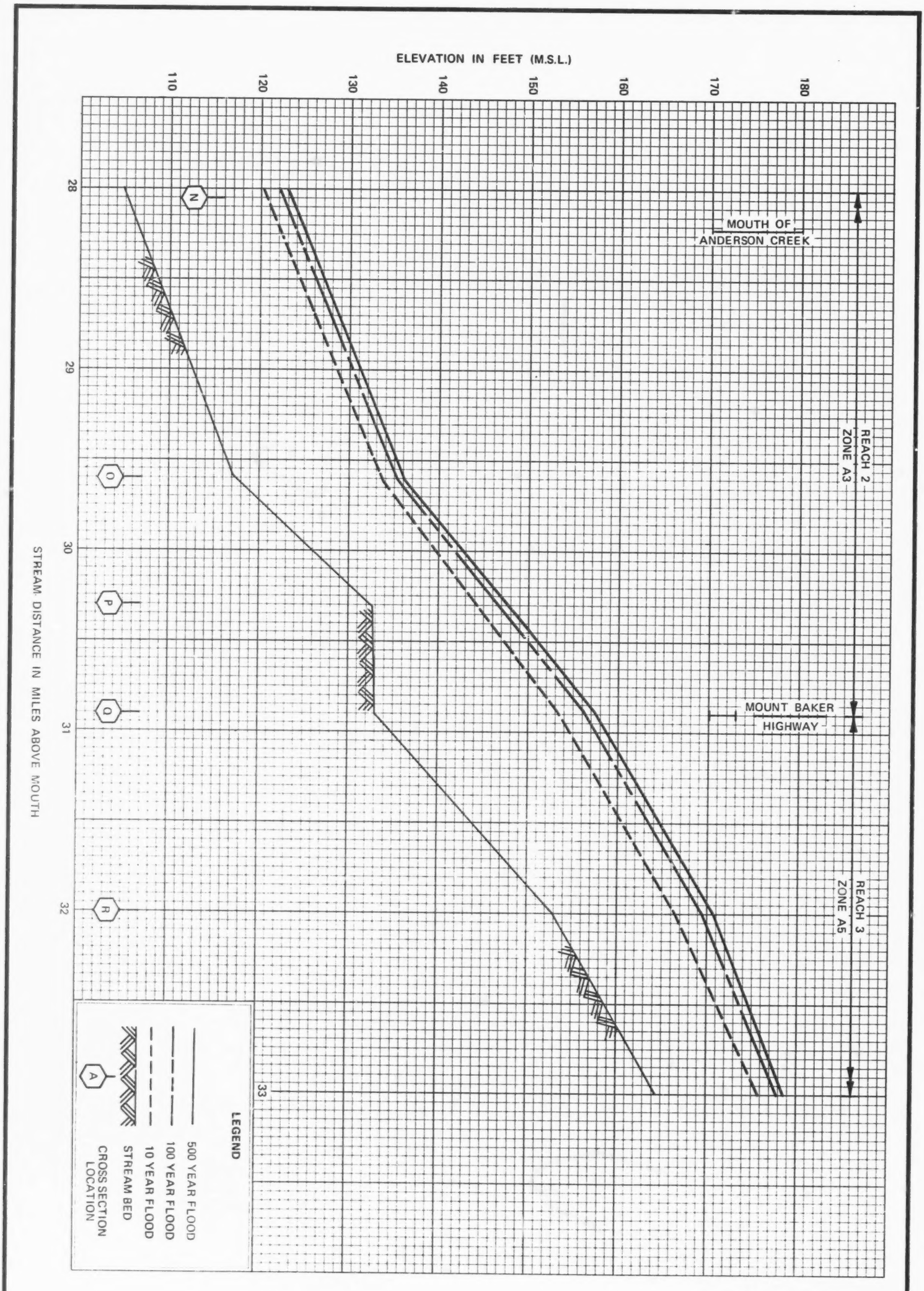


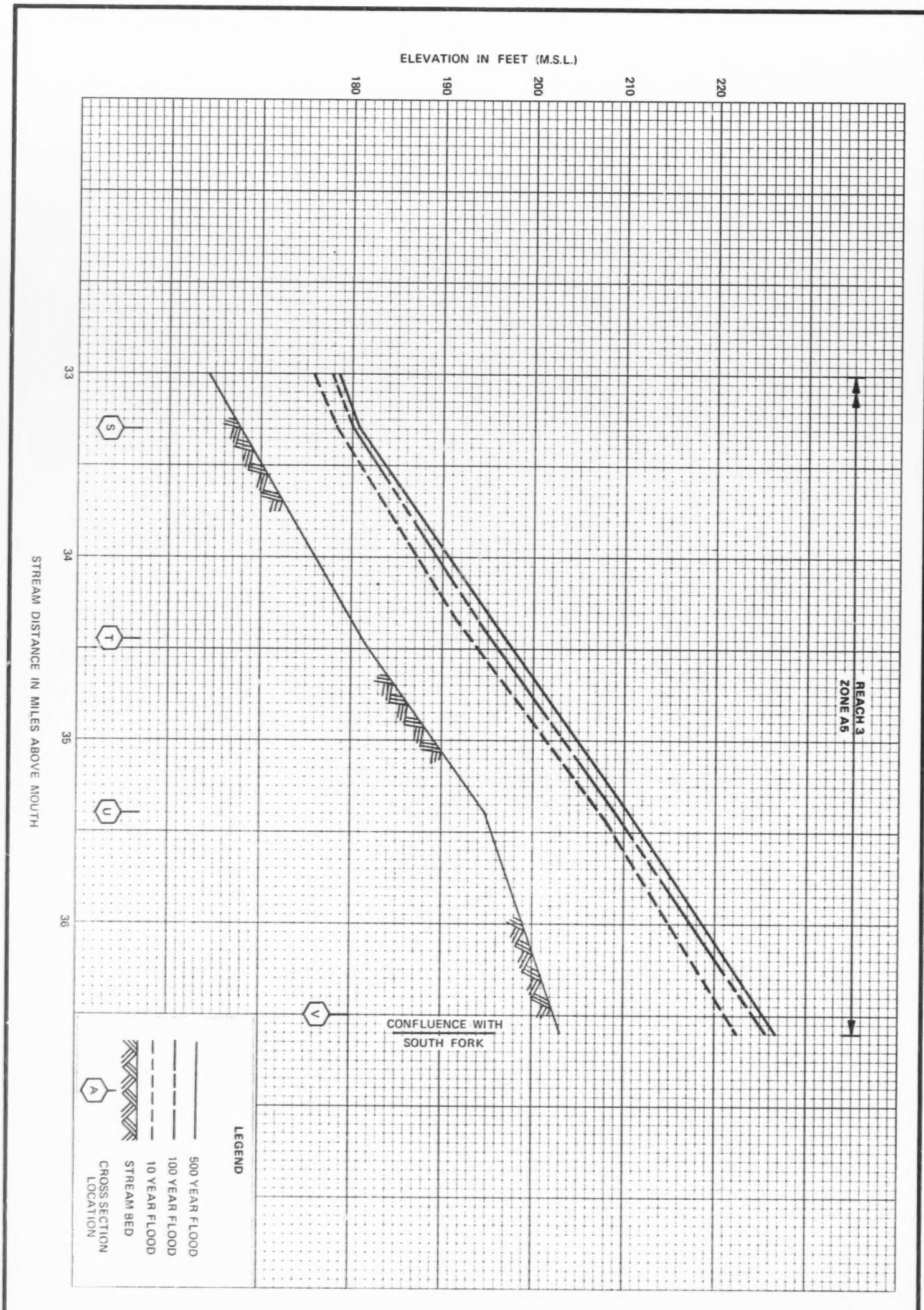
FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

NOOKSACK RIVER

07P



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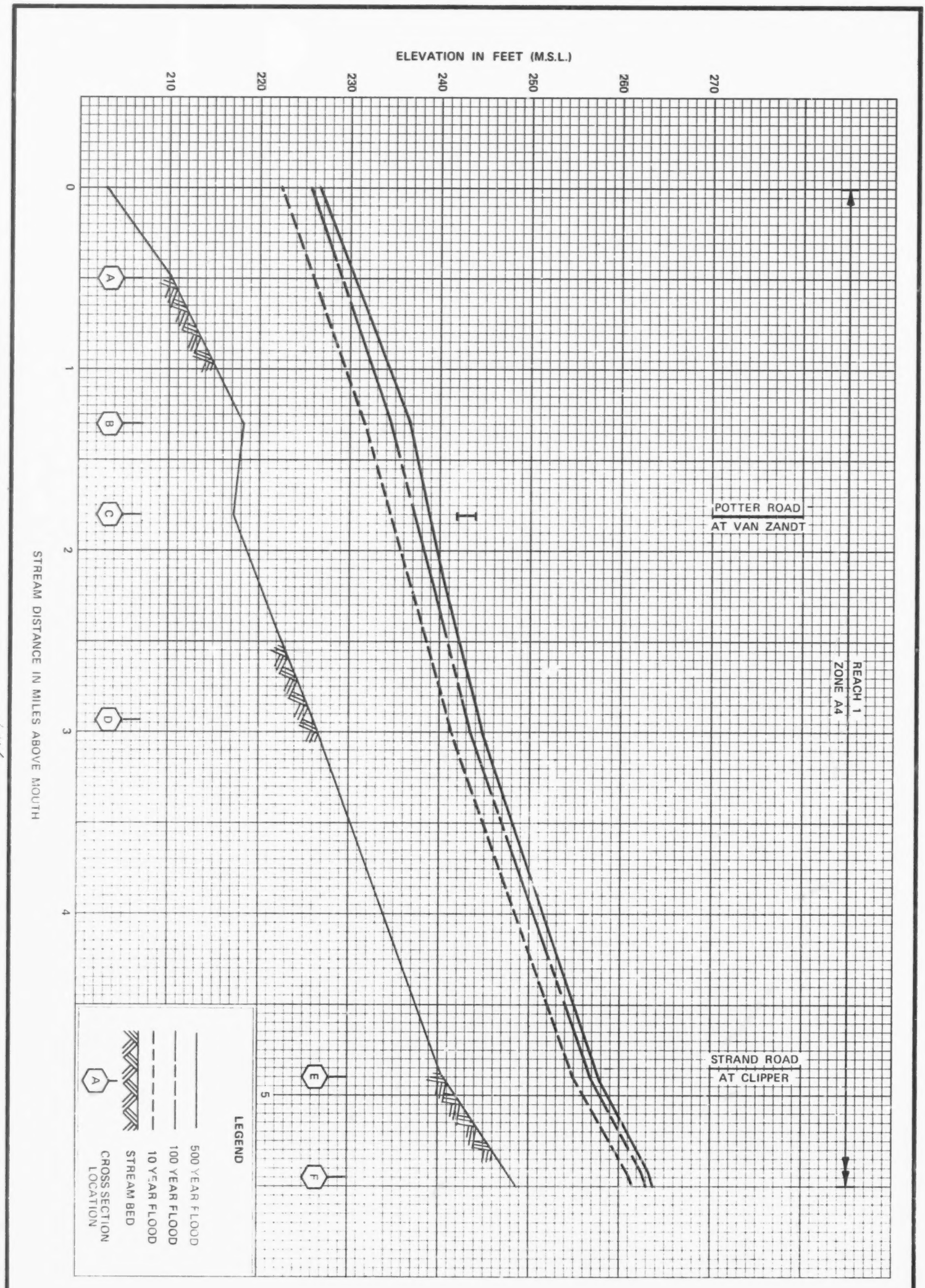


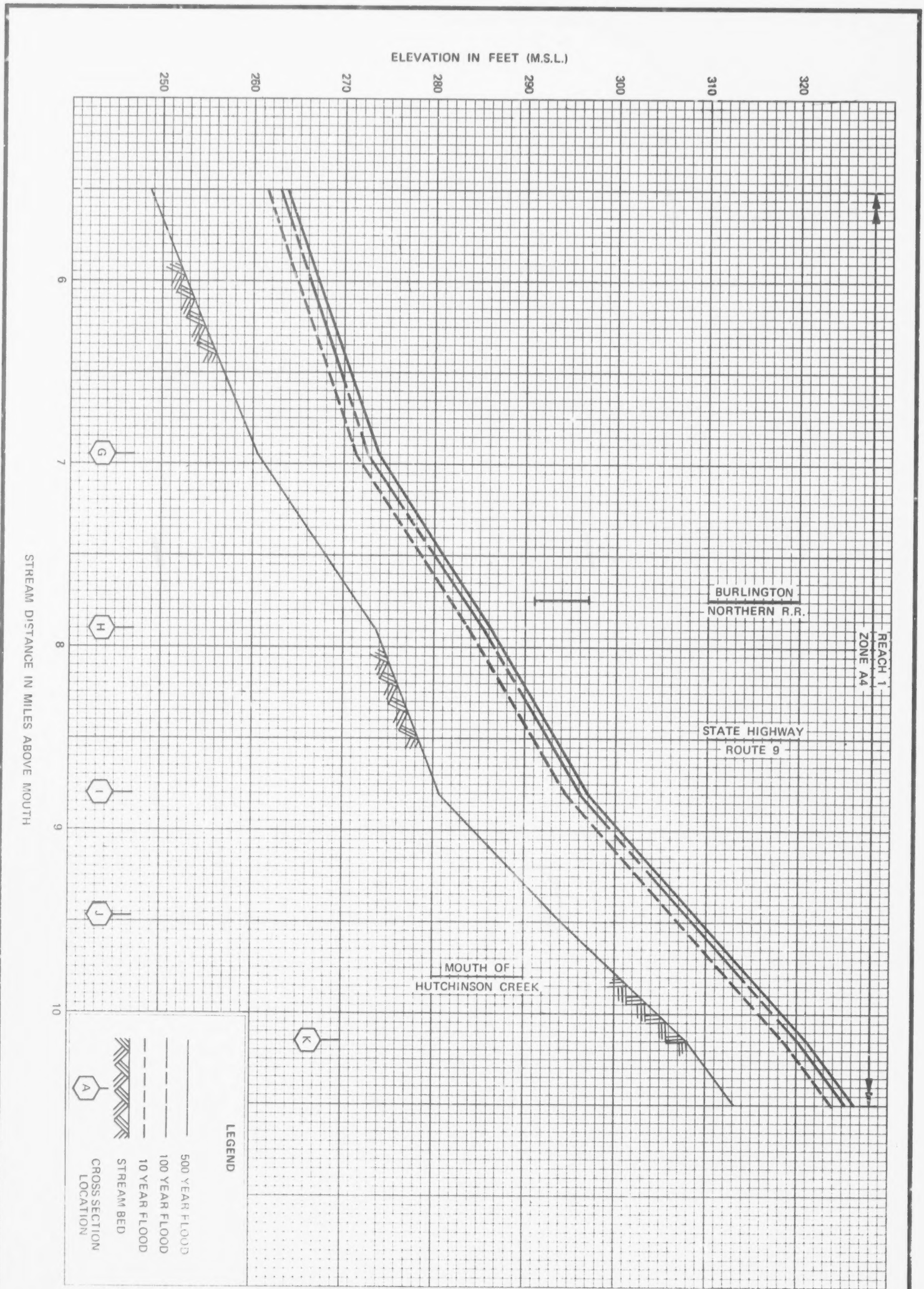
FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

SOUTH FORK NOOKSACK RIVER

09P



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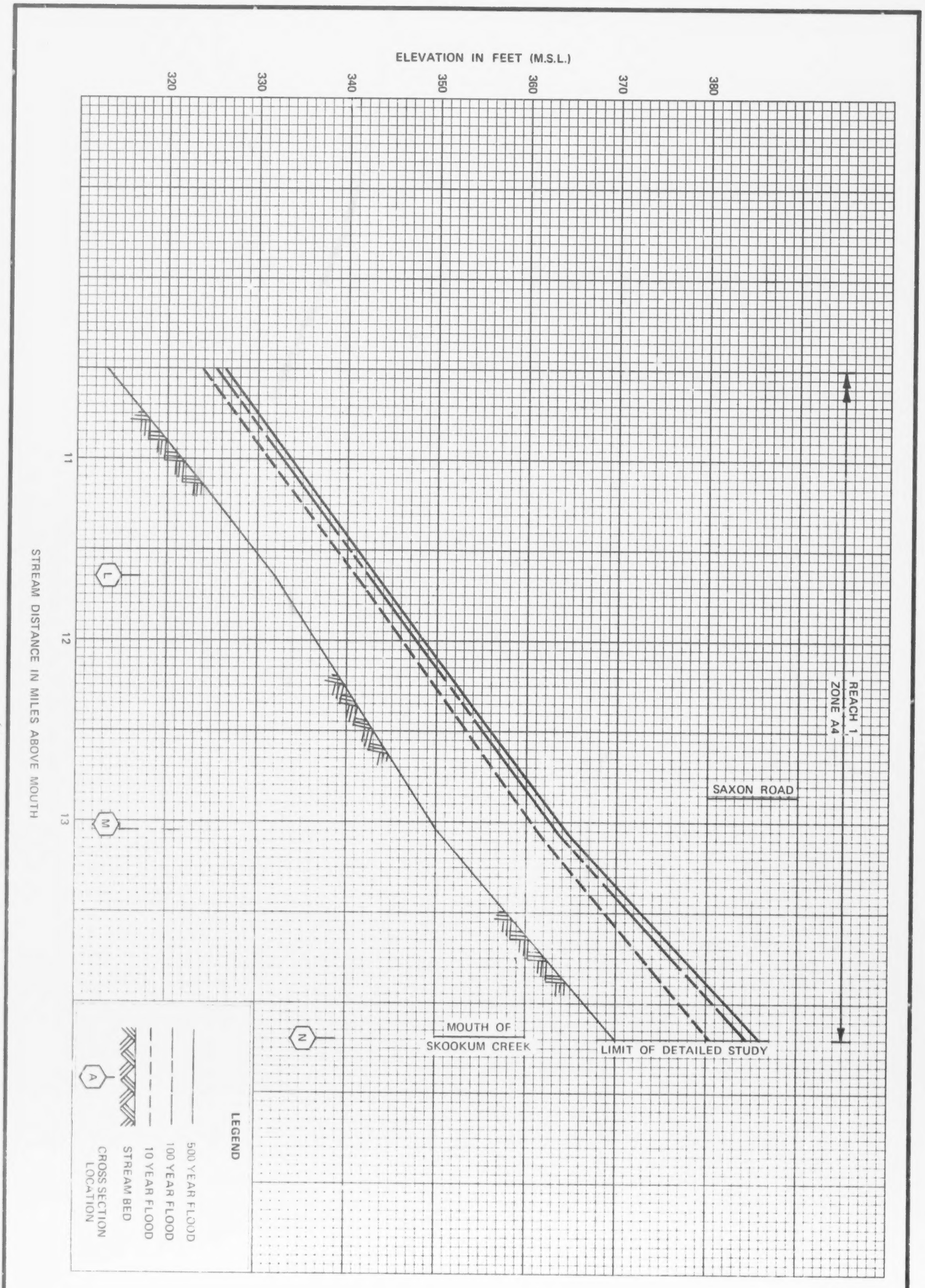
FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

SOUTH FORK NOOKSACK RIVER



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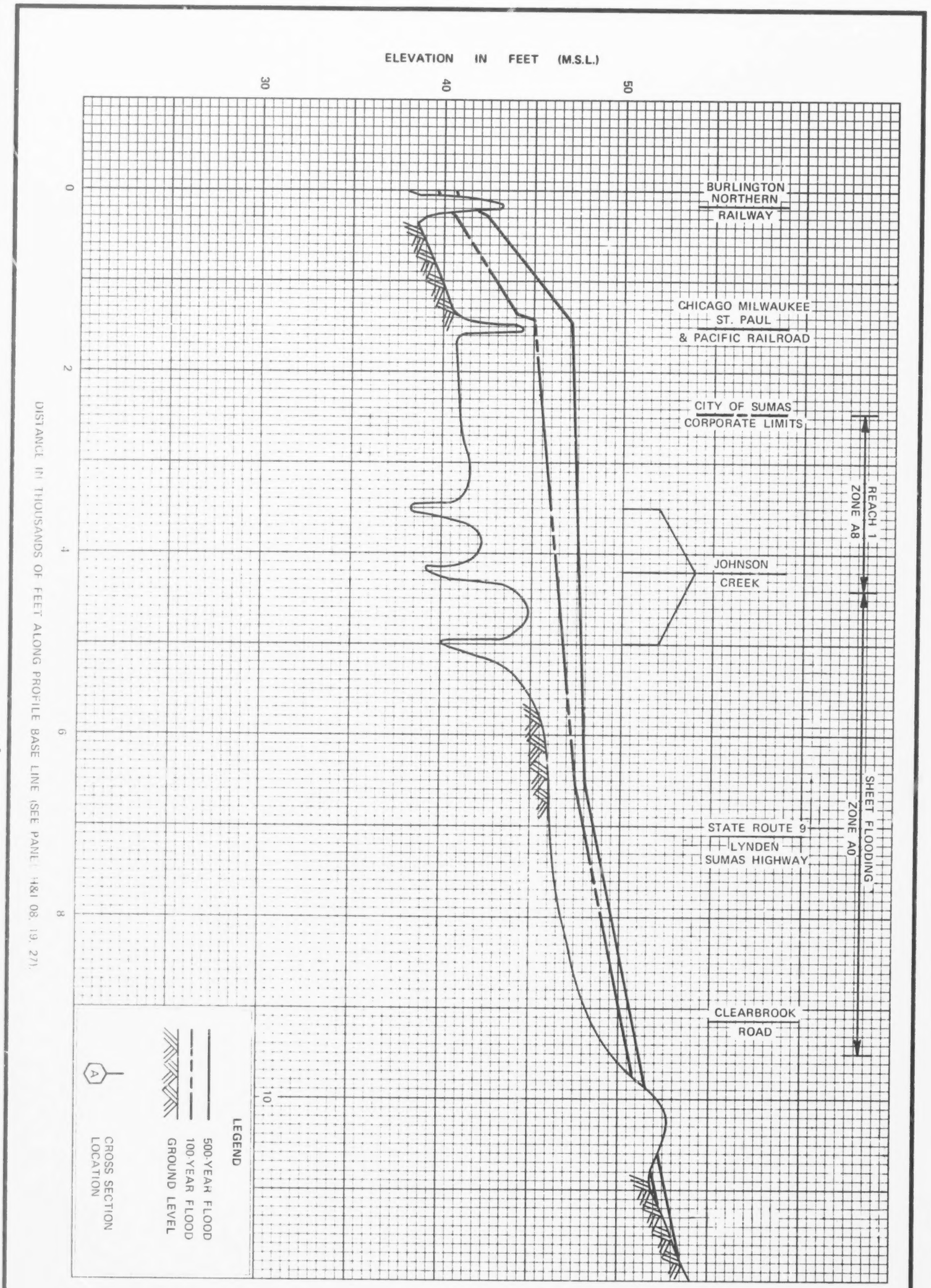

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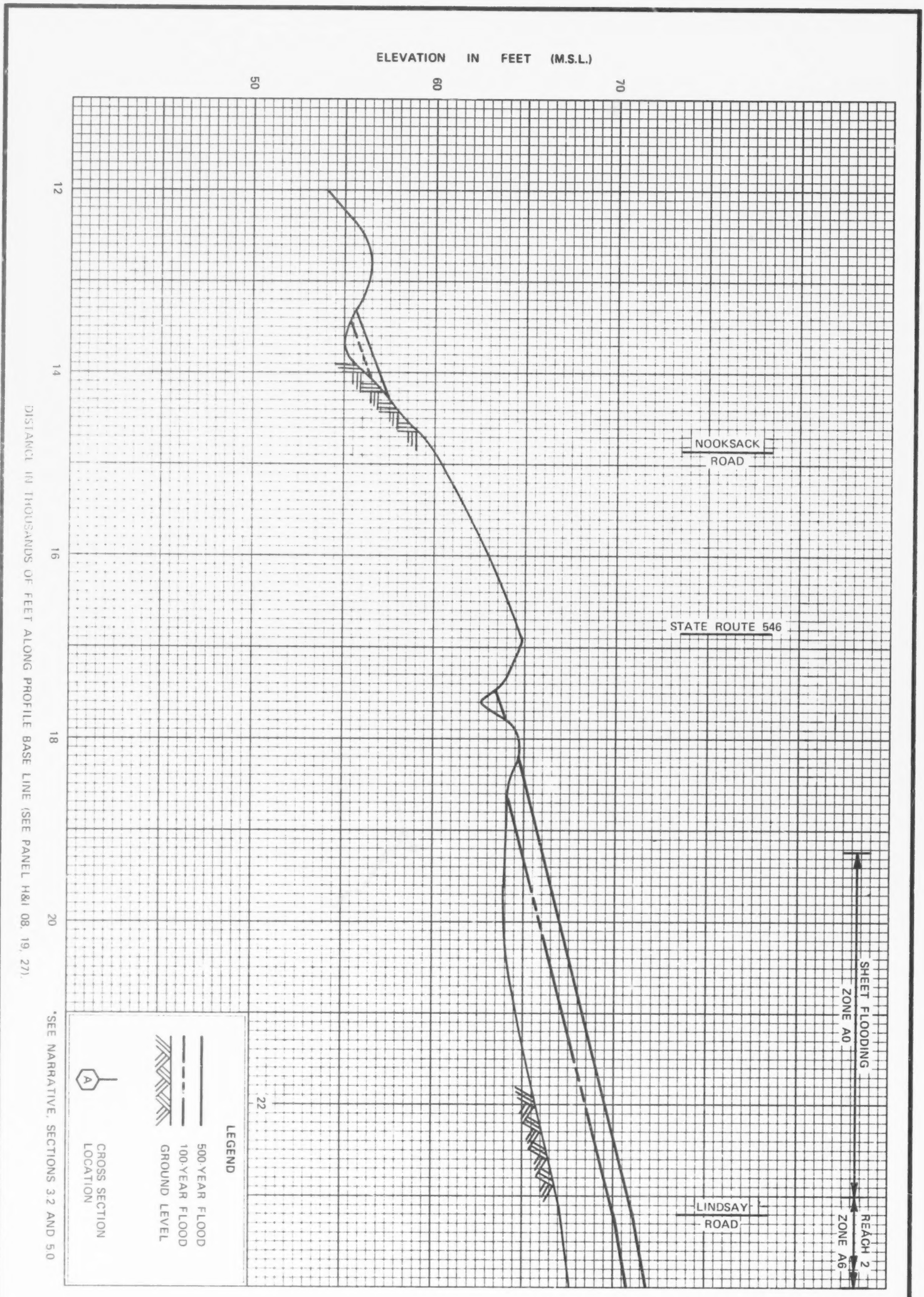
FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

SUMAS VALLEY OVERLAND FLOW



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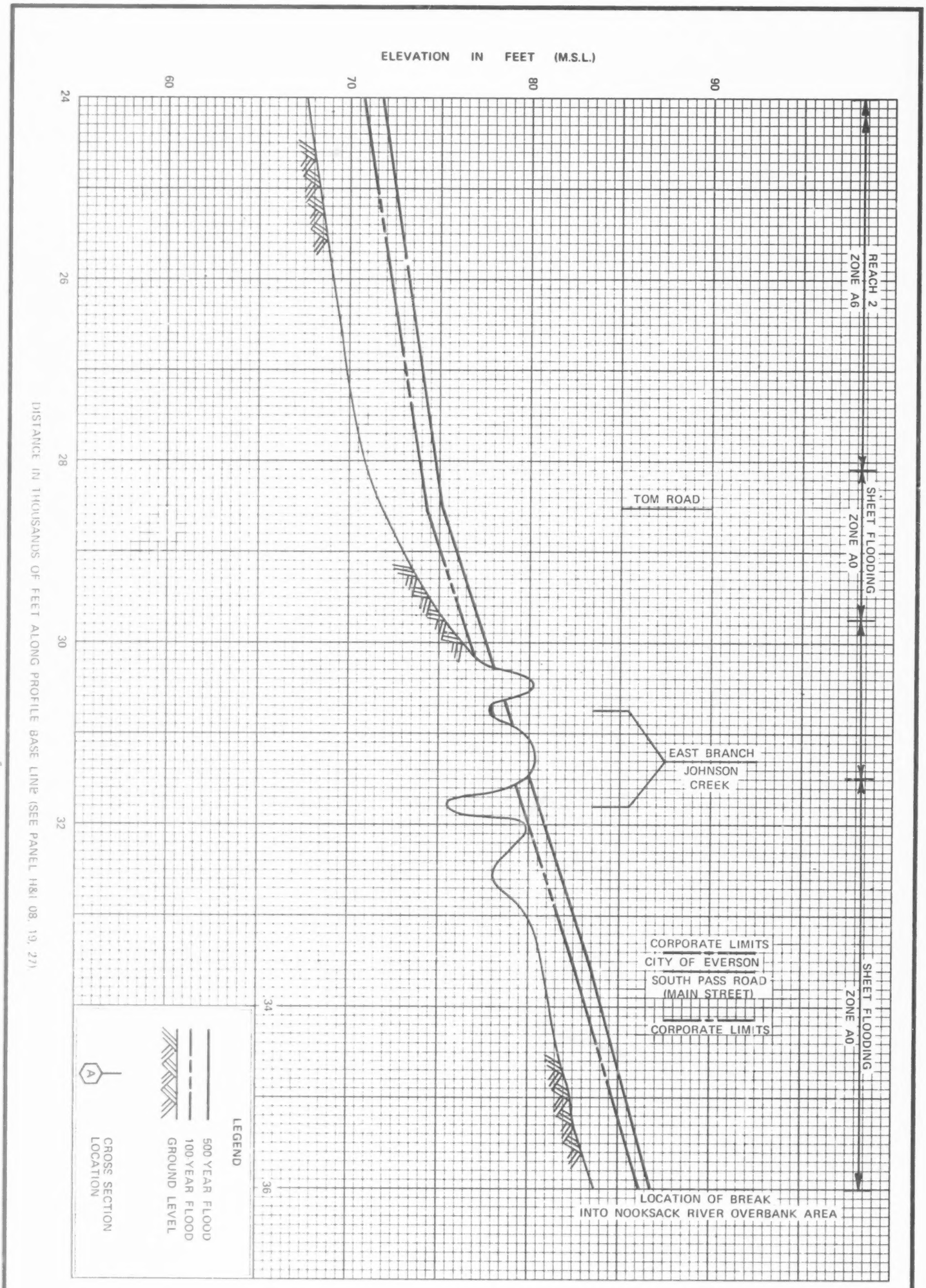
WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

SUMAS VALLEY OVERLAND FLOW



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FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM COUNTY, WA
(UNINC. AREA)

FLOOD PROFILES

SUMAS VALLEY OVERLAND FLOW

REFERENCE MARK	ELEVATION IN FT. (NGVD)[1]	DESCRIPTION OF LOCATION
RM 1	8.87	Top of bolt head on west side of telephone pole across road from east corner of post office.
RM 2	9.92	Top of head of railroad spike on east side of most downstream telephone pole at west end of Marietta bridge over main channel.
RM 3	14.87	Railroad spike in power pole by northeast corner of chicken shed on H. Telgenhoff farm.
RM 4	21.37	USGS bench mark disc monument outside of Paradise Road corner in section 20.
RM 5	43.81	Head of railroad spike in root of 36" maple tree (west side) 100 feet northwest of George Neevil farmhouse.
RM 6	35.43	Head of railroad spike in root of multi-stump maple tree 50± feet west of southwest corner of Woodland Dairy Farm hay shed.
RM 7	40.08	Head of bridge spike on northeast side of power pole 47 feet north of northeast corner of Rickenbacher farmhouse.
RM 8	24.44	Zero of Lynden Gage near Guide Meridian bridge.
RM 9	47.60	Standard brass cap in monument in north fence line along Bylsma Road east of 90 degree turn on line between sections 29 and 30.
RM 10	64.39	Chiseled square in top of west end of downstream, right-bank pier of former Hannegan Road bridge.
RM 11	66.45	Head of railroad spike on south side of power pole outside of Abbott Road angle at line between sections 26 and 27.
RM 12	78.01	Spike on centerline of River Road 18 feet from fence corner to south near north-south 1/4 section line in section 36.
RM 13	92.85	Chiseled square on northeast corner of sidewalk at west side of Sheffer farmhouse.
RM 14	128.52	Top of bridge spike on south side of 6" fir stump 500+ feet northwest of shed on Sheldon Ray Syre farm in section 17.
RM 15	157.35	Washington State Highway BM 22F. Brass disk in concrete footing to guard rail in S.W. corner of bridge on Highway 9 at Nugent's Corner.
RM 16	157.44	Chiseled square on north end, east guard rail footing on Highway 542 (1) bridge at Nugent's Corner.
RM 17	170.34	Top of "U" bend driven into most westerly of two 12-inch cherry trees, 118 feet north of wood bulkhead near abandoned railroad line in section 27.
RM 18	200.87	Steel pin in notch in root on northwest side of large maple tree 65 feet east of cattle shed and 2,000± feet southwest of Mt. Baker High School.
RM 19	220.73	USGS copper rail in most northerly of 2 concrete footings of gaging station support on right bank.
RM 20	232.75	Chiseled cross on northwest corner of left bank headwall of railroad bridge.
RM 21	231.75	Chiseled square in steel plate on top of west end of right bank bridge pier for Highway 9 (1A) bridge.
RM 22	239.50	Chiseled square on top of left bank pier, Van Zandt Bridge, north end.
RM 23	241.99	Railroad spike 1 foot above ground in downstream side of 3 foot diameter fir stump with cascara tree in top – 80 feet landward of bank riprap.
RM 24	281.56	Railroad spike in downstream riverward end of 18-inch cross beam of small railroad bridge over creek and farm road.
RM 25	289.13	Chiseled cross at downstream end of right river bank pier of railroad bridge north of Acme.
RM 26	298.65	USGS bench mark. Standard brass disc on top of west end of left bank pier of Acme bridge.
RM 27	365.25	Chiseled square on downstream anchor bolt, right bank concrete pier of new Saxon bridge.
RM 28	410.16	Top of 1/2 inch diameter bolt protruding from old concrete cattle guard on upstream side and 10 inches east of corner. Cattle guard 50 feet east of gaging station on left bank Skookum Creek – 25 feet downstream from center of gravel road.

[1]National Geodetic Vertical Datum of 1929.

ELEVATION REFERENCE MARKS

FEDERAL EMERGENCY MANAGEMENT AGENCY

WHATCOM CO., WA

01E